Drivers of agricultural losses in the Metropolitan Area of Barcelona: A temporal, spatial, and qualitative approach

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Research line: Integrated system analysis of urban nature-based solutions

Research group: Sostenipra

This work is based on an analysis of the process of agricultural loss in the Barcelona metropolitan area and the factors that explain this loss. As such, it is in line with the issues addressed within the Sostenipra research group, with the group that deals with integrated system analysis of urban nature-based solutions and even more specifically with the URBAG research project. Indeed, this research project explicitly investigates urban and peri-urban agriculture and its importance for ecosystem services provision and for urban resilience.
In this sense, the importance of understanding the drivers of loss of urban and peri-urban agriculture is crucial in order to understand what factors can enable it to maintain itself as a component of cities.
From a strictly research point of view, understanding the drivers of the loss and how this process is shaped at the spatial level, could be relevant to formulate scenarios of future spatial land use.

Description and guidelines

"Whether basic or applied, all Research Papers should describe the relevance of the work and its implications for landscape and urban planning, design, management and/or policy. Research Papers are typically between 4000 and 8000 words, including manuscript text and references (use 25-60 references as a guideline). Some exceptions to the upper length limit may be allowed for reports of large-scale interdisciplinary and transdisciplinary projects or for qualitative research where in-text quotations provide evidence in lieu of tables and figures. An abstract (250 words or less), keywords (3-6), and research highlights (3-5) are also required. Tables and figures should be used with economy to convey essential aspects about study concepts and findings. One or two contextual photos may be optionally included as figures to convey to readers the essential nature of the landscape and issues examined in the article. Other informative materials may also be optionally submitted, including Appendices, Acknowledgments, short Author Biographies, Graphical Abstracts, Google Maps (KML files), Embedded Audio and Video files, and Supplementary Material for online-only publication".

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Abstract

Urban and peri-urban agriculture (UPUA) is increasingly recognised as important for the wide variety of ecosystem services it can provide. Despite this growing interest, there is continuous process of loss of UPUA. Yet, underlying drivers of UPUA losses are still poorly understood.
This study examines the loss of UPUA in the Barcelona metropolitan area (AMB) from 2003 to 2015, the underlying drivers and possible strategies/policies to curb the loss process.
To assess specific UPUA land-use change dynamics spatial data provided *by Centro de Investigación Ecologica y Aplicación Forestal* (CREAF) were analysed to represent the quantitative and spatial change. In order to understand the drivers of land use change related to urban and peri-urban agriculture losses, as well as to identify possible strategies/policies to stop the loss of UPUA semi-structured interviews (n=7) with people from three different areas (research, public institutions and workers of the agricultural sector) have been carried out and analysed.
Results showed that most of the agricultural losses during the analysed time-period occurred between 2003 and 2007 with a subsequent gradual stabilisation. In this process a) some types of agriculture, have suffered higher losses than others; b) there is a marked difference between hill and flatland agriculture.
The analysis of the interviews shows that within the three macro drivers (socio-economic, regulatory, political) an important series of sub-categories are clearly identified by the interviewees.
Finally, five strategies/policies were identified in order to curb the loss of UPUA and enhance it. Theoretical and practical implications were discussed.

Keywords

Urban and peri-urban agriculture
Land use change
Urban Planning
Ecosystem services
Urban resilience

Highlights

- most of the agricultural losses during the analysed time-period occurred between 2003 and 2007 with a subsequent gradual stabilisation
- some types of agriculture, have suffered higher losses than others and there is a marked difference between hill and flatland agriculture
- loss of agricultural land in the AMB related also to planning policies, regulatory framework, and the general political approach of institutions

1. Introduction

According to UN projections, the number of people living in cities will continue to grow until 2050, reaching two-thirds of the world's population and more than eighty percent in Europe (UN, 2018).
Urban and peri-urban spaces are increasingly recognized for the possibilities they offer for urban spaces in shaping more liveable and sustainable cities (Cilliers et al., 2020).
In recent years, there has been a growing interest in urban and peri-urban agriculture (UPUA) as an important component of green spaces in urban contexts (Cilliers et al., 2020; Graefe et al., 2019).
This interest grew for two fundamental issues related to UPUA.
First of all, regard the opportunities for urban food production provided by UPUA (Opitz et al., 2016), concerning the opportunities offered by the short supply chain (Yacamán Ochoa et al., 2019), pushed even further by the effects that the covid-19 pandemic has had on food systems prompting to recognize how cities of the global north are in part dependent on the global food supply chain (Callau-Berenguer et al., 2022). This last point connects the (un)sustainability and vulnerability of the global supply chain (Benis & Ferrão., 2017) and the unfair socio-ecological teleconnections of shifting agricultural production from urban fringes to natural lands (Barthel et al., 2019) with the consequent embedded under-valued ecosystem services (Porter et al., 2014).
In second place concerning the multifunctionality that agriculture possesses with the various ecosystem services it can provide not only related to food production (Fanfani et al., 2022; Langemeyer et al., 2021), especially in the context of climate change (Lwasa et al., 2015). The ecosystem services (ES) that can be associated with urban and peri-urban agriculture are of all four macro types: supporting, provisioning, regulating, and cultural and its particularity lies in being in an urban and peri-urban context where the provision of ecosystem services is low (Wilhelm & Smith., 2018). Depending on the types of UPUA (in agronomic and socioeconomic terms) and the way is it managed, UPUA can provide specific ecosystem services such as carbon storage, biodiversity provision, pollination, urban micro-climate regulation, run-off mitigation, and maintaining the quality of urban and peri-urban soils and the associated ES (Calzolari et al., 2020; Lin et al., 2015; Wilhelm & Smith, 2018). Ecosystem services related to UPUA also contribute to social functions (and sometimes political functions) connected to community networks, political claims, and psychological individual well-being (Langemeyer et al., 2018). Moreover, given the above, UPUA could enhance urban resilience in a crisis context contributing to the adaptive capacities of the cities and regions (Langemeyer et al., 2021; Olsson et al., 2016).
These considerations lead to the importance of incorporating the urban dimensions of the agricultural-food system into the political agenda and thus into urban and territorial planning in order to strengthen the environmental, territorial, social, and economic sustainability and resilience of the urban context (Callau et al., 2017).
While there has been much focus on protecting nature in urban areas in recent years, the potential of urban and peri-urban agriculture remains overlooked in urban landscape planning. UPUA has historically been ignored by urban planners on the general grounds that agriculture is a rural issue and as such is outside the domain and interest of urban planning (Morgan., 2009). Therefore, agriculture is seen within urban planning as a rural issue to the point of considering agricultural land within the urban context as a space waiting to be developed (Ilieva., 2016).
Even when formally recognized within urban planning through urban containment or zoning programs, the pressure on agricultural land in the urban context does not stop, given the strong socio-economic pressures that exist with respect to the possibility of changing land use of agricultural land (Olsson et al., 2016).
As a consequence, the area devoted to agricultural production in the surrounding of cities is declining at a global scale (Bren d'Amour et al., 2017; García-Nieto et al., 2018; Zoomers et al., 2017). Within the European context, peri-urban agrarian spaces have suffered greatly and most from urbanization pressure, in the period 1990-2000 it was estimated that 77% of new urban land occupied agrarian areas (Rojo et al., 2017).
The drivers of UA losses are still poorly understood. Such understanding is yet pivotal to stopping the ongoing decline in urban and peri-urban agriculture.
This paper aims to contribute to understanding the drivers of UPUA loss. Through the adoption of a holistic perspective that connects urban planning, historical processes, economic structures, and socio-cultural

changes. The specific objectives of this study are threefold: 1) to gain a spatially differentiated understanding of land use change connected to losses in UPUA 2) to understand and analyze the underline drivers of UPUA losses; and 3) to identify possible strategies/policies to stop the loss of UPUA. The study builds upon the process of agricultural land loss in the Metropolitan Area of Barcelona (AMB) in the period 2003-2015 as a case study.

2. Study area

The AMB includes 36 municipalities, has a geographical surface area of 63.600 ha and a population of about 3.3 million, thereby accounting for one of the most populated areas in Europe. The population in the AMB has seen a process of strong growth during the 20th century, rising from 614,120 in 1900 to 3,230,337 in 2014 (IDESCAT., 2022). The AMB is characterized by a Mediterranean climate (with hot, dry summers and mild winters and two rainy seasons concentrated in spring and autumn), which makes it possible to produce a wide variety of crops. In 2010, Law 31/2010 was passed, initiating the process of creating a new general urban planning plan called the 'Pla Director Urbanistic metropolità' (PDU). From a regulatory-administrative point of view, the PDU represents a special case in the European context since it is a land use plan common to all the municipalities of the Barcelona metropolitan area (Cirera and Giocoli., 2022). Among the objectives of the plan is a strong emphasis on the creation of a resilient city with a focus on ecosystem service-based urban planning – with UPUA as a strong focus.

Yet, looking at the history of the AMB, more than seventy per cent of agricultural land has been lost in the past fifty years (Paül., 2016). In this regard, it is important to mention the “Pla General Metropolitan” (PGM) made in 1976 and is still currently in force. One of the important objectives of this plan was to regulate urban growth, including through the creation of large urban parks such as the Collserola area, and to define much of the land of Vall Baixa and the Llobregat Delta with the creation of the legal figure of “Parc Agrari de Llobregat” as agricultural protection land (Parcerisa., 2013). However, at the same time a part of the cultivated land was classified as urbanizable and this has a major effect on land of agricultural value, which thus remained unprotected (Tendero et al, 2016). More in general this has resulted in agriculture taking on a less prominent role in urban planning since it is considered a 'reserve space' (Carril., 2010). In quantitative terms, when the PGM was implemented in the AMB, there were 10,804 cultivated hectares of which 4,256 with irrigation, of these the PGM provided for the protection of only 2,817 and they correspond almost entirely to the current Parc Agrari del Baix de Llobregat (Carril., 2010).

The area dedicated to agriculture is around 8.5% of the AMB, compared to an urbanized area of 53.9% (Sigcpack 2015); this means about 16/m^2 of agricultural land per inhabitant (IERMB, 2016). The agricultural land is mainly concentrated in the Delta and the Vall Baixa of the Lobregat river; we also find agriculture in the urban edges of towns located in the Serra de L'ordal, the Valles, the Serralada Marina and the Collserola area.

Many agricultural areas that resisted the urbanization trend, are currently in a state of abandonment (Tendero et al., 2016).

The agricultural land in the AMB can be categorized into different types of production regarding its socio-economic ends: professional agriculture (with an explicitly productive function), urban horticulture gardens with social and community functions, and as well as familiar/informal horticultural gardens (Pirro & Anguelovski., 2017; IERMB., 2017).

3. Methods

3.1. Spatial and quantitative analysis.

In order to gain a better understanding of the process and drivers of agricultural land loss in the Barcelona metropolitan area, first, a spatial analysis of land use change related to agriculture was conducted. To assess

specific UPUA land-use change dynamics in the last two decades we analyzed data provided *by Centro de Investigaciòn de Ecologica y Aplicación Forestal* (CREAF) depicting the state of land cover in the Barcelona Metropolitan Area (CREAF, 2015). These data are composed of four different layers representing four different moments in time 2003,2007,2009 and 2015. Each one of these four layers addresses the land cover in the AMB at that respective moment in time and is represented in vector format.
As software to process the data QGIS 3.16.6 and ARCGIS 10.8 were used.
The data were analyzed searching for a possible standardization to find a minimum common baseline of comparison for different categories of analysis and different detail of analysis identifying in "Cat_Niv_1" the most general level of comparison possible and in "Cat_Niv_3" the most detailed level of comparison possible, thus creating a "dictionary" for comparing the data.
After that, the data on the state of land use were used as input to produce other layers representing the processes of overall land use change between different layers and thus between different moments in time. making it possible to analyze the change overall (2003 to 2015) and between individual years, (2003-2007, 2007-2009, 2009-2015) to see how the change evolved in the timeframe considered.
At this point, two parallel processes were carried out.
Process 1) Sankey diagrams were produced to represent the patterns of change of the quantitative loss of agricultural soil at the most general level possible "Cat_Niv_1" and at the most specific level possible "Cat_Niv_3" by also analyzing the changes within the various categories representing agricultural land.
In the latter case, it was decided to exclude three LU-categories "Artificial channel", "Agricultural ponds" which accounted for less than one percent of agricultural land, and "Waters" which accounted for less than one percent of agricultural land conversion.
Furthermore, it was considered appropriate to merge the categories "Abandoned crops-meadows" "Abandoned crops-shrubland" and "Abandoned crops-forest" into a new category called "Abandoned crops". In addition, three categories were merged 'Greenhouses', 'Vineyards' and 'Crops in transformation'(See appendix A for the Sankey Diagram representing these three categories) for two reasons: because of a need in terms of visualize the major patterns of change in the Sankey Diagram and because "Greenhouses" and "Vineyards" are two categories with almost no overall variation.

Cat_Niv_1	**Cat_Niv_2**	**Cat_Niv_3**
Cultivated land	Cultivated land	Abandoned crops-meadows
Cultivated land	Cultivated land	Abandoned crops-shrubland
Cultivated land	Cultivated land	Abandoned crops-forest
Cultivated land	Cultivated land	Crops in trasformation
Cultivated land	Cultivated land	Herbaceous plants cultivated land (no rice fields)
Cultivated land	Cultivated land	Woody plants cultivated lands (no vineyards)
Cultivated land	Cultivated land	Greenhouses
Cultivated land	Cultivated land	Vineyards
Informal garden	Informal garden	Informal garden

Table 1. Hierarchical organization of LU categories considered.

Process 2) The maps representing general land-use change were used as input to produce other maps showing only those changes involving the loss of agricultural land. The level of detail chosen to represent the change was "Cat_Niv_3" but in order to represent the major spatial patterns of change, a process of aggregation was performed here as well. The categories "Cultivate woody plants (not vineyards)" and "Vineyards" were aggregated into a new category "Cultivate woody plants", the same thing was done for " Cultivate herbaceous plants (not rice fields)" and "Greenhouses" resulting in the new category" Cultivate herbaceous plants". The category "Informal garden" appears to be from 2007 because it was not present in the 2003 layer.
Concerning the categories replacing agricultural land, it was decided to maintain the "Cat_Niv_1" level and not keep only the "Waters" category, as it represented less than one percent of agricultural land replacement.

For the graphical representation (Fig 3) it was decided to eliminate the changes concerning the loss of agricultural land <100 m2.

3.2. Semi-structured interviews.

To understand the drivers of land use change related to urban and peri-urban agriculture losses, as well as to identify possible strategies/policies to stop the loss of UPUA semi-structured interviews with people from three different areas: research, public institutions, and workers of the agricultural sector representatives have been carried out. Relevant interview partners were selected to have a perspective that encompasses all drivers and their possible connections. Interviews were conducted between June and July 2022 (n=7, three men and for women), the modality was both face to face and online, with respect to interview availability.
In the analysis of interview results, respondents belonging to public institutions will be marked with the letter A, those belonging to the research world with the letter R, and those working within the agricultural sector with the letter F.
The interviews were conducted in Spanish with a duration of approximately one hour each interview and were fully registered, after formal permission of all interviewees.
The phase of constructing the agenda for the interview guide, the outline of planned topics and the question to be addressed was guided on the one hand by some references from the relevant literature and on the other hand by the quantitative data and their mapping. Of particular importance concerning the literature used were the two reports of the IERMB (IERMB., 2016; IERMB., 2017), the set of monographs by (Tendero et al., 2016), and the study by (Paul., 2010). Particular attention was given to different rates of agricultural land loss in different timeframes, different types of crops and land use change, forest lands and urbanized lands in relation to agricultural land loss, and the interaction among different UPUA actors. See appendix B for the full interview guideline.
All the interviews were transcribed in Spanish. The results of the interviews were organized following a mixed deductive and inductive coding process depending on the research question addressed. See (Saldaña., 2013) for a description of the coding process. A manual coding process was chosen due to the exploratory nature of this research and the small amount of textual data to be examined.
In order to understand the loss drivers of UPUA codes representing the three macro drivers explaining change processes (socio-economic, regulatory, and political) were set a priori (macro-categories). This initial coding process allowed the text to be divided into a few very large portions. Subsequently, based on the answers given by the respondents, further codes were added articulating different aspects of each macro-category.
About the identification of possible strategies/policies to curb the loss of UPUA, the method followed was exclusively inductive without any a priori coding.
At this stage of the research, the distribution of the informants' answers, divided into the three classes (R, A, F), in the macro- and sub-categories will not be examined.
This study has two main limitations. The fact that there is no data available from 2015 to 2022 to see whether there has been a relative recovery in the rate of loss of agricultural land and the relative sample population on which the interviews were conducted.

4. Results

4.1. Land-use changes

Through the analysis of the data, three important trends have been noted. The first is that most of the agricultural losses during the analyzed time period occurred between 2003 and 2007 with subsequent gradual stabilization of the process of agricultural land loss. The second high-level observation is that some types of agriculture, namely “Cultivated herbaceous plants (no rice fields)” and “Cultivated woody plants (no vineyards)”, have suffered higher losses than others, such as “Others”.

The third is that patterns of change showed signs of difference between hill and flatland agriculture, the former showing a pattern of loss from arboreal cultivation to forest land due to abandonment, while the latter shows a pattern of loss from herbaceous crops to urbanized areas.

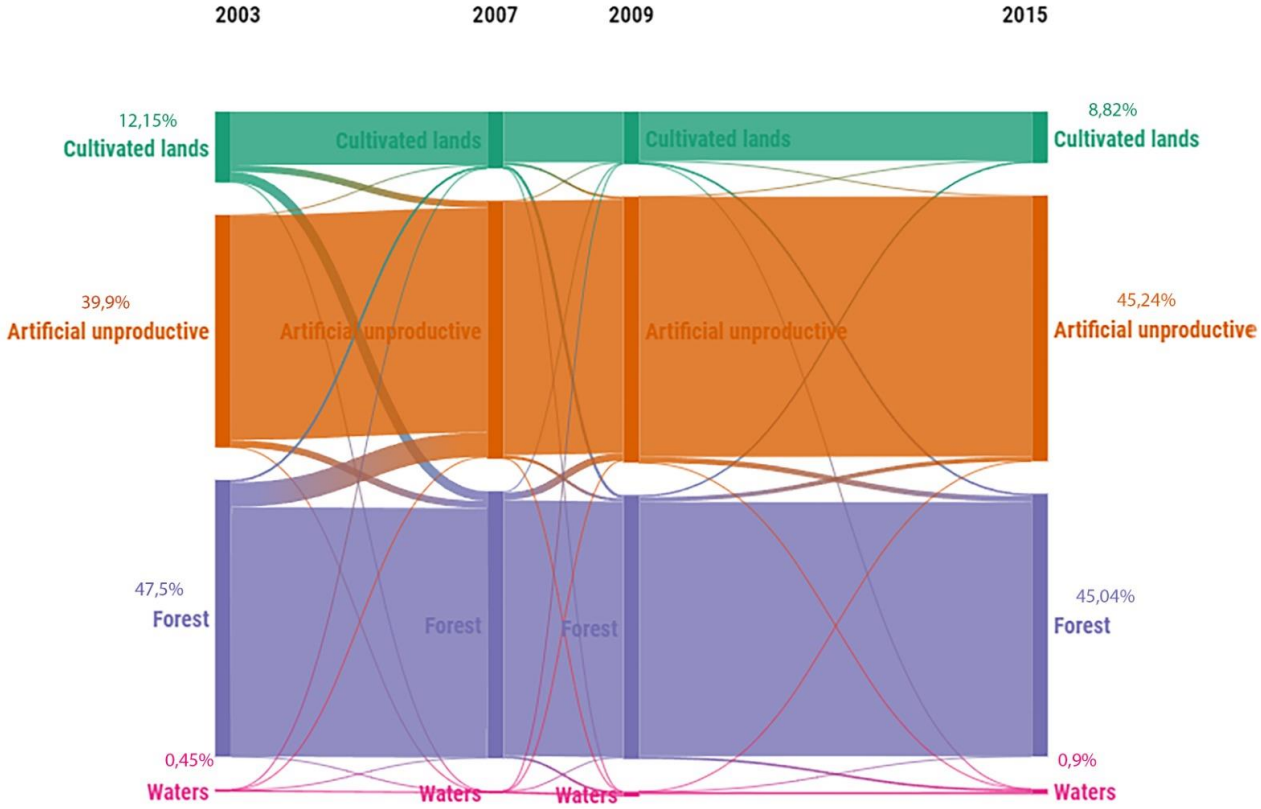

Fig. 1. Sankey Diagram of UPUA loss based on Cat_Niv_1. CREAF categorization. Source: reworked from CREAF data.

The first trend can be seen in the first Sankey Diagram. Agricultural land is replaced, on the one hand, by forest land and, on the other hand, by urbanized land. This change occurred mainly from 2003 to 2007 in which the area of agricultural land lost 1.918,44 hectares of arable land, while from 2007 to 2009 660,31 and from 2009 to 2015, 394,35 hectares. This result shows, as mentioned, a stabilization of the process of agricultural soil loss until 2015.

As regards the categories of land cover replacing agricultural soil, we see that the category "Forest " is the category that contributes the most to the loss of agricultural land, followed by "Artificial unproductive" and finally “Waters”.

According to CREAF's data, in 2003 12.15% of the territory was represented by agricultural land, in 2015 this surface had shrunk to 8.82%, of this percentage lost 2.11% in favor of "Forest", 1.66% in "Artificial unproductive" and 0.24% in favor of “Waters”.

Regarding the agricultural categories disaggregated to the Cat_Niv-3 level, the following results were noted.

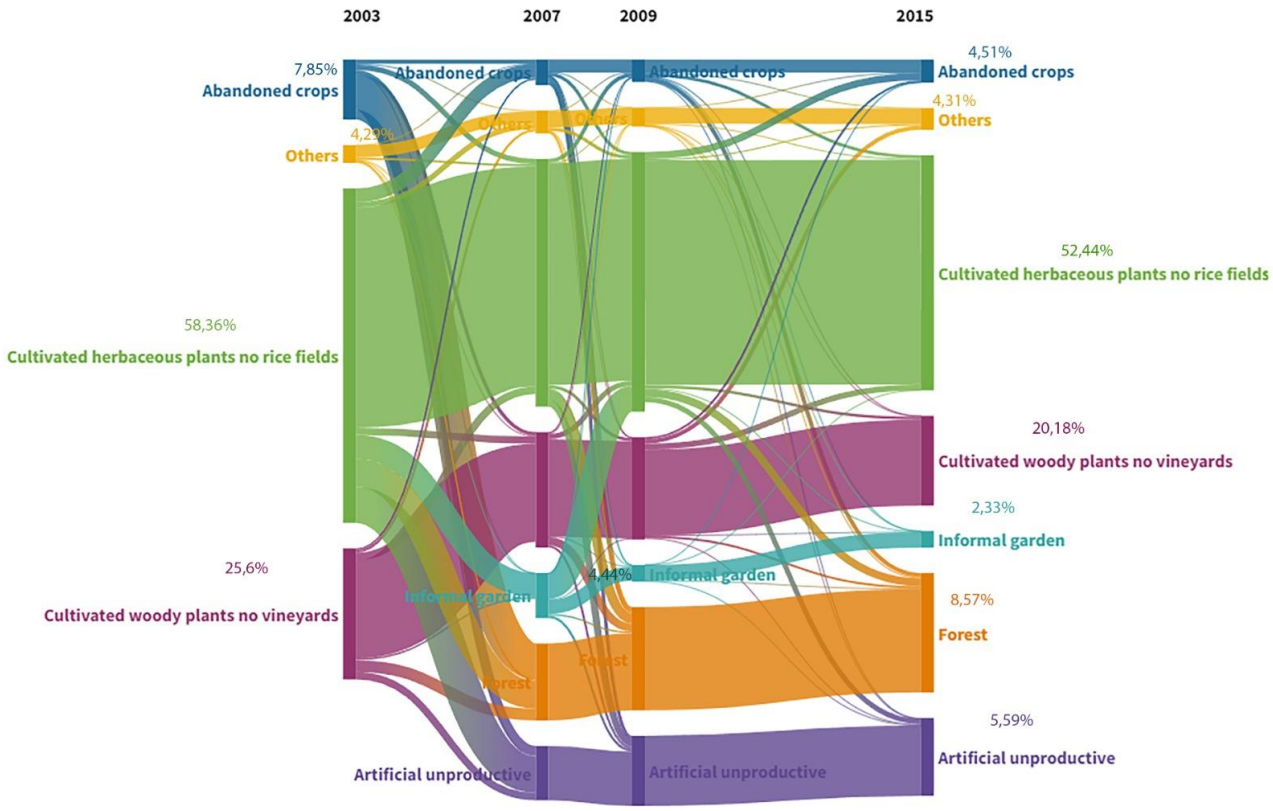

Fig. 2. Sankey Diagram of UPUA loss based on CAT_Niv_3. CREAF categorization. Source: reworked from CREAF data.

Most of the change regarding the category "Abandoned crops" went toward "Forest lands" corresponding to 635.79 ha, and towards “Artificial unproductive” with 200.63 ha of change. The change of this category also went towards other agricultural categories, in order of importance towards “Cultivated herbaceous plants” (171.91 ha), “Cultivated herbaceous plants (no rice fields)" (59.21 ha), and “Informal garden” (2.89 ha).
The largest agricultural category "Cultivated herbaceous plants (no rice fields)" had a change mainly towards the category "Artificial unproductive" (683.23 ha) change, towards the category "Forest" (643.98 ha), the change towards "Abandoned crops" (349.84 ha) is also relevant.
Coming to the category "Cultivated woody plants (no vineyards)" the main directions of change went respectively towards “Cultivated herbaceous plants (no rice fields)” (261.98 hectares), towards "Forest" (312.17 ha) and towards "Artificial unproductive" (149.97 ha), it is also relevant to note that there are two minor directions of change towards “Abandoned crops” (79.16 ha) and “Others” (17.02 ha).
Regarding the category “Others” (as previously said resulting from the merge of three categories (“Vineyards”, “Greenhouses” and “Crops in transformation”) there were no major overall changes in the area of agricultural land that’s because of the two categories that mainly make up show no signs of general change. See the supplementary material B for a Sankey Diagram of the category “Others” disaggregated into its component categories.
Finally looking at the category “Informal garden” the main line of change went towards “Cultivate herbaceous plants” (362.44 ha) again there are two minor directions of change representing a loss of agricultural land towards "Artificial unproductive"(40.94 ha) and "Forest" (32.35 ha) respectively.
At the percentage level, the category “Abandoned crops” went from 7.85% in 2003 to 4.51% in 2015, losing 3.25% in favour of” Forest lands”, 1.03% in favour of” Artificial unproductive”. Only 0.88% went towards “Cultivated herbaceous plants (no rice fields)” (showing a change in favour of agricultural land).
"Cultivated herbaceous plants (not rice fields)” (the category that lost the most in absolute value) lost more than 10% from 58.36% in 2003 to 47.88% in 2015. Compared to this loss, the major directions of change are

3.49% towards “Artificial unproductive”, 3.29% towards "Forest”, 1.79% towards "Abandoned crops" and 0.97% towards "Cultivated woody plants (not vineyards)".
"Cultivated woody plants (not vineyards)" (the category that lost the most in comparison to its land cover in 2003) fell from 25.06% in 2003 to 20.18% in 2015. This loss was mainly in “Forest” 1.6%, “Cultivated herbaceous plants (not rice fields)1.34% and “Artificial unproductive” 0.77%.
The 'Others' category, as mentioned, did not show any particular signs of net change.
Through spatial analysis, three main areas of agricultural soil loss were identified within the AMB, each of them representing specific dynamics.

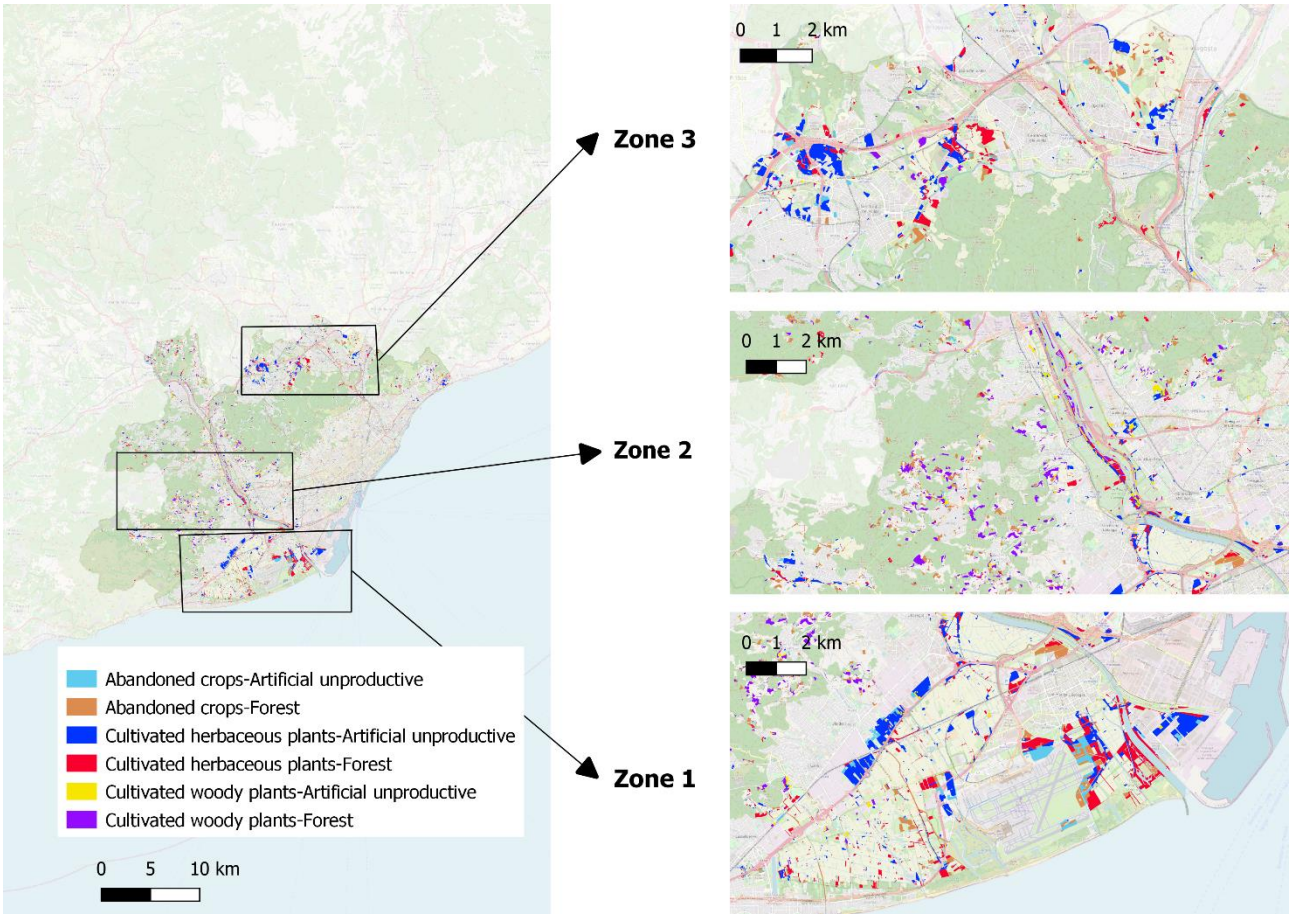

Fig. 3. Map representing spatial pattens of change of UPUA loss.

1) The first area identified, concerns the area of the Llobregat delta comprising the metropolitan municipalities of 'El Prat de llobregat', 'Sant Boi de Llobregat', 'Viladecans', 'Gavà', 'Castelldefels' and “Cornellà de Llobregat”. In the first area identified, we see four types of LU-changes, two major and two minors. Starting with the first two, there is a change from 'Cultivate herbaceous plants' to 'Forest lands' and from 'Cultivate herbaceous plants' to 'Artificial unproductive'. In smaller and more fragmented areas, however, there is a change from 'Abandoned crops' to “Artificial unproductive” and from “Abandoned crops” to “Forest lands”. Finally, we find small and fragmented areas of change from 'Cultivate woody plants” to “Artificial unproductive”.

2) The second area identified concerns the course of the river Llobregat and the hilly areas to the east and west of the river comprising the metropolitan municipalities of 'Begues', 'Sant Climent de Llobregat', 'Torrelles de Llobregat', 'Santa Coloma de Cervello', "Sant Vicenc dels Horts', 'Cervellò', 'La Palma de Cervellò', 'Pallejà', 'Corbera de llobregat', 'Sant Andreu de la Barca', 'Castellbisbal', 'El Papiol', 'Molins de

Rei', 'Sant Feliu de Llobregat', 'Sant Joàn Despì' and 'Sant Just Desvern'. In the second zone, we have two main lines of change scattered throughout the area and three minor ones concentrated in certain points. The main ones concern the change from “Cultivate woody plants” to “Forest lands” and from “Abandoned crops” to “Forest lands”. Two minor LU-changes can be observed from "Cultivate herbaceous plants" to "Forest lands" and from "Cultivate herbaceous plants " to "Artificial unproductive" mainly concentrated in the areas belonging to the municipalities of "Begues", "Corbera de llobregat" and "Castellbisbal". Instead, the last line of change from “Cultivate woody plants” to “Artificial unproductive” is concentrated along the banks of the Llobregat river.

3) The third zone covers the north-west of the Barcelona Metropolitan Area and includes the municipalities of 'Sant Cougat del Valles', 'Cerdanyola del Valles', 'Ripollet', 'Barberà del Valles', 'Montcada y Reixac', 'Badadalona' and 'Montgat'. In the third zone, there are five types of LU changes, three major and two minors. The major changes are represented by "Cultivate herbaceous plants" to "Artificial unproductive" (with a greater concentration in the area pertaining to the municipality of Sant Cougat del Valles), "Cultivate herbaceous plants" to "Forest lands" mainly concentrated in the areas pertaining to the municipalities of Sant Cougat, Cerdanyola del Valles. "Abandoned crops" at "Forest lands" are homogenously distributed across the zone. The two minor exchange categories are identified in "Cultivate woody plants" in "Forest lands" located almost exclusively in the area between Sant Cugat del Valles and Cerdanyola del Valles. Finally, there is also a change from “Abandoned crops” to “Artificial unproductive” located in the areas around Sant Cougat del Valles, Ripollet, and Montgat.

4.2. Drivers of change

Three macro drivers of agricultural land loss emerged from the analysis of interviews conducted with actors connected to UPUA. The three macro-drivers are: 1) socio-economic driver; 2) regulatory driver; 3) political driver. Subpoints were identified for each driver and are described in the following.

4.2.1 Socio-economic drivers

a) The “green revolution”2
Concerning this driver, it is necessary to start with a historical perspective analyzing changes that occurred on a larger scale but also affected the BCA, for the respondent R1 emphasizes that:
“Industrialisation of agriculture green revolution which meant abandoning all land on slopes that were difficult to mechanize for extensive cultivation, often with trees or shrub” subsequently adding that this happened because” […] *the first selection criterion was basically the slope and therefore the depth of the soil, and the green revolution has kept the flattest and deepest soils* […]*”.*

b) UPUA is not profitable
In this new economic context, the UPUA becomes less and less profitable as the A1 interviewed stated *“*[…] *what a farm produces, respecting the work that you put in, the gross margin, if the land is difficult to work, the margin is so small that when the land is no longer good, you may not be able to work it. The margin left by the land is getting smaller and smaller, it is disappearing because they are not profitable, only those that are profitable are cultivated* […] *“adding that”[….] if the profitability is lower and lower, you don't invest and you end up closing down and this is what happens to peri-urban agriculture* […]*”* the respondent R1 added that “ [...] *there they are already competing with the prices of what comes from all over the world Africa and Latin America*”. These market dynamics have 'affected' some types of production more than others as explained by F1 “[…] *but in the Delta [de Llobregat] and the Vall Baixa, what has been lost is fruit growing, which has been transferred to horticulture, but this is not only a territorial factor, it is also a factor related to the market, to changes in the market and the management of the crops* [...]*”.*

c) Urban pressure and speculation

A key phenomenon has been urban pressure in all its various forms. This is underlined by all the respondents, quoting respondent A2" [...] *in peri-urban areas and areas closer to agglomerations is the high pressure of demand for land for other activities and speculation which means that agricultural land is worth one and urbanized land is worth one hundred* […]*"* respect this an important role was played by the real estate bubble of 1996-2007 as another respondent (A3) says *"*[…] *this strongest agricultural loss is linked to the real estate boom* […]*"*. In this process, as several interviewees stated, strategies are often adopted in which agricultural land is bought and degraded in order to be able to build, in particular, respondent F1 specifies that *"*[...] *what is in the agricultural area that is abandoned or degraded by other uses is clearly the process of speculation* [...]*"*.

d) Fragmentation of agricultural land and the problem of water access

This strong urban pressure has led to a process of fragmentation of agricultural land and competition for water use. In this respect is prominent the role of infrastructures, this issue is well explained by interviewee A1*"*[…] *a road has a very specific effect on that area, it hurts the agricultural sector, and this also affects production. When you have to build a road, you have to analyze not only the hectares occupied/lost but also what happens in the surrounding 200 hectares, whether it continues to be viable or not (for example, I have interrupted the communication routes, there is no easy access), it turns out that it was not an impact of 20 hectares but an impact of 200"*. Fragmentation has mainly affected some type of cultivation with longer production cycles as another respondent (F1) affirms *"*[…] *a tree needs a few years to be in full production then of course if you don't have stability in the soil, you don't know when a cable or whatever is going to go through the ground* […]*"*. Furthermore, the same respondent (F1) underlined the fact that for hillside farming areas there is the central problem of access to water *"*[...] *the mountain areas have been abandoned because they are not economically viable and because they basically have no water* […]*"*.

e) Economic behaviours of farmers and cultural praxis

This unstable economic environment has influenced the economic behavior of farmers, quoting A1 *"*[…] *So what does a farmer do in a place that has a lot of investment possibilities? Maybe they don't invest in their plots because they have other opportunities that are much more profitable and then there is a lot of urban pressure, the vocation of those farms is not to remain agricultural* […]*"*. This interacts with cultural practices of generational transition with respect to land cultivation. This relation between tradition-cultural changes-economic and land structures is well explained by the interviewee F1 *"*[…] *right now the paradigm is that it is my children who have to continue with the farm if your children already know that they are not going to continue then why do you want that land anymore because when the sentimental value has passed then you want to sell it to the one who pays you the most, which is not going to be another farmer but a builder"*.

4.2.2 Regulatory drivers

a) Focus on pristine nature overlooking agriculture

At the regulatory level, there was a focus at the European level on nature protection, originally excluding agriculture, quoting R1*" the construction of natural parks, which in the first stage was done with a very short-sighted and protectionist approach of doing nothing or removing human action, agriculture is superfluous in this vision of nature* […]*"*. Even at the time level there was a mismatch between nature protection and agricultural protection as A1 explained *"*[...] *the <<ley de Marco Agricola>>, which was introduced now, was not introduced in the years 80-90-2000 when all the habitat protection directives appeared. Unlike the habitat law, the agricultural law is not a European directive [….]"*. This European regulatory paradigm was translated into the <ley forestal of Catalonia (1988)> as the respondents A3 stated" […] *more value to the forest practically qualified a large part of these mountain territories, even if they had been cultivated in the past, they were all qualified as forest, so there was a prohibition practically to remove the trees, which was also the traditional way in which they did it, absolutely a little artificialized, also due to the strict regulations"*.

b) Limited accounting of UPUA by urbanistic planification

From the point of view of urban planning, respondents pointed to the 1976 master plan and its inherent contradictions as A3 specifies *"*[…]*the PGM foresaw extensions of industrial polygons that were then built occupying at that time land that was agricultural, so only the area of the Delta de Llobregat linked to the whole discourse of the agrarian park was protected* [...] *while in general and agricultural land was seen as something waiting to be let's say urbanised anyway with other uses* […]*".* The lack of recognition of the value of urban and peri-urban agriculture is also identified as a preconception about agriculture on the part of urban planners according to A1 *"*[…] *for urban planners, where there is nothing is where there is agricultural activity, they use the word "polygon of economic activity" polygon of economic activity is the whole territory, not just a single area where there is an industrial polygon".*

c) Land lease dynamics

The fact that it is much easier to access land for actors whose aim is to change the use of agricultural land than for other farmers interested in continuing farming is not only related to the strong asymmetries in this market but also the forms associated with the land lease. In this regard, respondent F1 states the following: *"*[…] *a farmer does not manage to consolidate the farm because a farm contract is for 7 years, and nobody wants to lease for 7 years because it makes no sense to invest for 7 years".*

4.2.3 Political drivers

a) **Lack of political interest in maintaining and improving infrastructure useful for UPUA**

From public policy authorities, there has been a huge underestimation of the value of peri-urban agriculture to gain access to large economic revenues, using the words of A2 *"*[…]*at the political level it is still not clear to them they do not see it clearly they want to continue using the land for urbanization and to organize it because it is the way they generate more income at the local level* […]*".*These types of actors have also contributed to the perception of urban and peri-urban agriculture as a degraded space to be redeveloped according to R1 *"*[…] *the city councils that are also underfunded are used to getting resources to then make parks or public space or whatever it takes to get people to vote for them again, so the easiest income they can get is just to requalify, so it is enough to convince these people that look what a mess you have here and look how nice these blocks of flats I am proposing are going to be* [...]*".* In this regard, it is important to state the role that public administrations could play in relation to UPUA, which from an economic point of view would not be too costly as A1 stated *"*[…].*with the power that the city councils have, the money that has to be invested is not significant, what has to be invested with respect to the GDP that is around for example the airport is ridiculous or what has to be invested is that there has been no political will, there is no economic sector that has wanted that to be economically powerful because it wants to have it as a land reserve* […]*".*

b) Conflict among UPUA actors

The UPUA in the Barcelona metropolitan area is composed of different profiles of farmers and agricultural practitioners, which stands partially in conflict with each other. From the point of view of professional farmers (F1), informal or non-professional farming is a problem because *"*[…] *for professional agriculture it is a reason for the degradation of the territory, and it is a very, very big inconvenience for the farmers who still persist. In Sant Feliu they are real heroes because they [non-professional farmers] steal the water, invade the roads so that on Sundays the professional farmers cannot go to work because the roads are full of parked cars, and there is a very unpleasant situation when they cannot irrigate. The water issue is a very unpleasant situation, the Canal de la Infanta, has some [organized irrigation] turns, which are not respected, so they cannot irrigate when it is time* […]. *So, the coexistence between this type of [non-professional] agriculture and professional agriculture is very difficult* […]. In addition to this, the fact that in that area, Sant Feliu non-professional farmers are renting small plots of land which distort land prices as A3 explained *"...from San Feliu [non-professional farmers] should be taken out because they [non-professional farmers] distort the market* […]*".* On the other hand, however, the same respondent adds that informal agriculture is also a form of UPUA and so "[...]*it is a fact let's say that this need for informal gardens needs to be met* […]*".*

4.3 Possible strategies to stop the loss and foster UPUA

In addition, a point was identified related to what can be done to stop the loss of agricultural land and strengthen UPUA in the Barcelona metropolitan area.

a) Infrastructure useful for UPUA
One of the first actions identified to strengthen UPUA is the infrastructure needed for agricultural activity according to A1: *"*[…] *If there are no infrastructures, they will not be viable. That is, this economic activity zone (agriculture) must have the infrastructures and services so that it can develop efficiently* […]". The same respondent added that infrastructures are mainly related to water management and supply *"some irrigation systems can increase productivity by a factor of twenty, a very effective tool"*. This is particularly important for hill farming (F2): *"*[…] *so if you want to keep that as an agricultural area and also fruit and vegetable production, you have to bring water and you have to invest, the public administration has to invest* […]*".*

b) Recognition of the resilient function of the agroforestry mosaic
Regarding hill farming in the Barcelona metropolitan area an important strategy to preserve, according to F2, is *"*[…]*to convince park managers that certain agricultural and forestry activities are very important to maintain a mosaic landscape which is very important to differentiate habitats, host biodiversity and a better management of fires avoiding that the opposite happens the spontaneous reforestation that has occurred from this dynamic of abandonment that leads to a very homogeneous forest with very low biodiversity*[…]*".*

c) Payment for ecosystem service
Taking into consideration the difficult economic 'structures' in which UPUA farmers operate one necessary action is to subsidize farmers for the farming activity itself and for the ecosystem services they provide, using the words of A2 *"*[…]*So here we conclude that if we want to maintain the little agriculture that is left in these cities in San Cugat and in other towns that are close to big cities and with many infrastructures that cross us, the only way to maintain agriculture is to subsidize the remaining farmers and pay them to cultivate these fields because if you don't pay them, it is not worth it for them* […]". Along these lines respondent A3 remarked *"*[…]*it seems rationale to already think about paying the people they cultivate for the ecosystem service they provide* […]*".*

d) Creation and implementation of agricultural parks
The legal form that allowed the AMB to maintain agricultural 'clusters' was the 'parc agrari'. In this respect, A2 states *"*[...]*in other words, if you create an urban planning formula that allows you to block the agricultural land and with this it will not be possible to build, but if there is no urban planning formula that allows you to create an agricultural park like the one in Llobregat or the one in Mollet, then you are already lost* […]*".*

e) Recognition of the value and functionality of informal gardens
The phenomenon of informal gardens represents an important demand that could be recognized and valorized in A3 opinion *"*[…] *however, to recognise this demand is important to find places where these community gardens can be created. For example, using interstitial spaces on the edges of urban areas that are close enough to the city and so easily reached. At the same time [informal gardens] also serve a little bit to order the relationship between the urban and the non-urban in the rural, therefore would be good transitional spaces* […]*"*. This is also particularly important because inter- and transitional spaces represent a particularly harsh environment for professional agriculture as the same respondent added *"*[…] *in these spaces that are more fragmented and more degraded due to infrastructure this could be an opportunity for improvement. For a professional farmer, it does not make sense to produce there while for informal forms of production it does, we can even start talking that then they can become communitarian, therefore recognized and therefore formal* […]*".*

5. Discussion & Conclusions

Combining a spatial analysis and qualitative interviews applied to the analysis of the Barcelona Metropolitan Area, this study offers insights into the process of agricultural land loss from 2003 to 2015 and the underlying driving processes. It emerges that the main dynamic related to agricultural land is not that of an internal change but that of its total decrease. In the timeframe analyzed there was a clear trend of loss of agricultural land in favor of Forest land on the one hand and urbanized areas on the other. This result is in line with the trend identified by the analysis of (Paul, 2010) up to 1999 concerning the AMB. However, this trend shows a decreasing rate of agricultural land loss, thus showing signs of stabilization in more recent years.

Patterns of change show signs of difference between hill and flatland agriculture, the former showing a pattern of loss from arboreal cultivation to forest land due to abandonment, while the latter shows a pattern of loss from herbaceous crops to urbanized areas. This has implied the loss of the agro-forestry mosaic (and associated biodiversity), which is progressively replaced by woodland (Carril., 2010), and the fragmentation of agricultural activity in the interior with the consequent proliferation of marginal agricultural land uses, these have also developed in the vicinity of infrastructure or on land that seems to be waiting to undergo a process of construction (IERMB., 2016).

Through the semi-structured interviews with key stakeholders, the drivers of loss were analyzed, which correspond on one hand to punctual moments found in spatial and quantitative change such as the real estate bubble (and the subsequent economic crisis in 2008) and on its effects on land-use change, on the other hand to longer-term and “structural” processes that also encompass the 2003-2015 change.

Three macro-drivers were identified: economic, regulatory, and political drivers, each of them subdivided in turn into more specific sub-categories. The division into these macro-categories was made out of an analytical and categorization need, because, in reality, these drivers show themselves to be intrinsically interrelated at different spatial and temporal scales with possible reinforcing mechanisms.

Although it is true that the increase in land value based on the possibility of urbanization and economic expectation generates a process of agricultural land abandonment (Naredo and Zaldivar., 2008) it seems reasonable to state that the loss of agricultural land in the AMB is not only related to population growth and associated market-driven processes but also planning policies, regulatory framework and the general political approach of institutions to the UPUA (Lawton & Morrison., 2022) and the function of land tenure regime as emerged in other keys studies (Wästfelt & Zhang., 2018). For instance, there are relatively few areas in mountainous areas that are recognized as being in agricultural use, instead recognized as forest (agricultural land that was abandoned). Land that is very difficult to return to agricultural use because the forest is considered a system to be protected regardless of its ecological value (Tendero et al., 2016).

The difficulty of integrating the value of the UPUA within urban planning is not only related to a lack of space in and around cities but also a factor related to political will and framework (Aubry et al., 2012). In this regard, it is important to note that a key limitation concerning the possible support of administrations at all levels towards UPUA is related to the fact that the importance of UPUA is often linked only to its performance in terms of productivity, ignoring by many stakeholders, especially those belonging to institutions involved in urban planning, all the other multifunctionalities associated with UPUA (Sanyé-Mengual et al., 2020.). In the case of the AMB, this is evident with respect to the disregard, or even demonization, of informal agriculture (Pirro & Anguelovski., 2017).

In addition to the drivers underlying the loss of UPUA, strategies have been identified, that can be implemented at the city, regional and national levels to stop the loss and enhance UPUA and its various forms. In this regard, although there has indeed been a loss of productive importance of UPUA (Rojo et al., 2021) for AMB, nevertheless it is possible and necessary to integrate it into a policy framework where its value is not only strictly related to production. These possible policy actions can be implemented in favor of UPUA but also address interrelated but separate areas to that of UPUA such as ES, resilience, biodiversity, and the maintenance (or recovery) of cultural heritage and cultural landscape (Pérez-Campaña & Valenzuela-Montes., 2015; Zazo et al., 2020).

Even in the case of the production function of UPUA one should not give up thinking and implementing urban food strategy through the integration of food issues into urban planning. This could be achieved through the maintenance of existing "Parc Agrari" and the further creation and implementation of others (Zazo et al., 2020), contributing to the city's food resilience and helping improve urban-rural relationships as

the 'food cells' model suggests (Callau et al., 2017). But more in general the production function and possibility of UPUA should be integrated into the broader production capacity of the region, as recommended by the city region food system approach (CRFS) (Blay-Palmer et al., 2018).
In this context, the new urban plan of the metropolitan city of Barcelona, the Pla Director Urbanistic (PDU), represents an important opportunity to re-frame UPUA. This is so because of its emphasis on planning based on ecosystem services, its recognition of the fundamental importance of 'green infrastructure, its connection with UPUA (Rolf et al, 2020), and the possibility of coordinating all 26 municipalities comprising the AMB (Cirera and Giocoli., 2022).
Given these objectives and tools, this master plan could be an important first step in the recognition of the importance of UPUA and its value in terms of providing ecosystem services and a key element in the city's resilience. It is also important for this recognition to come not only from the world of 'urban planners' but also from the political and social city context.

6.References

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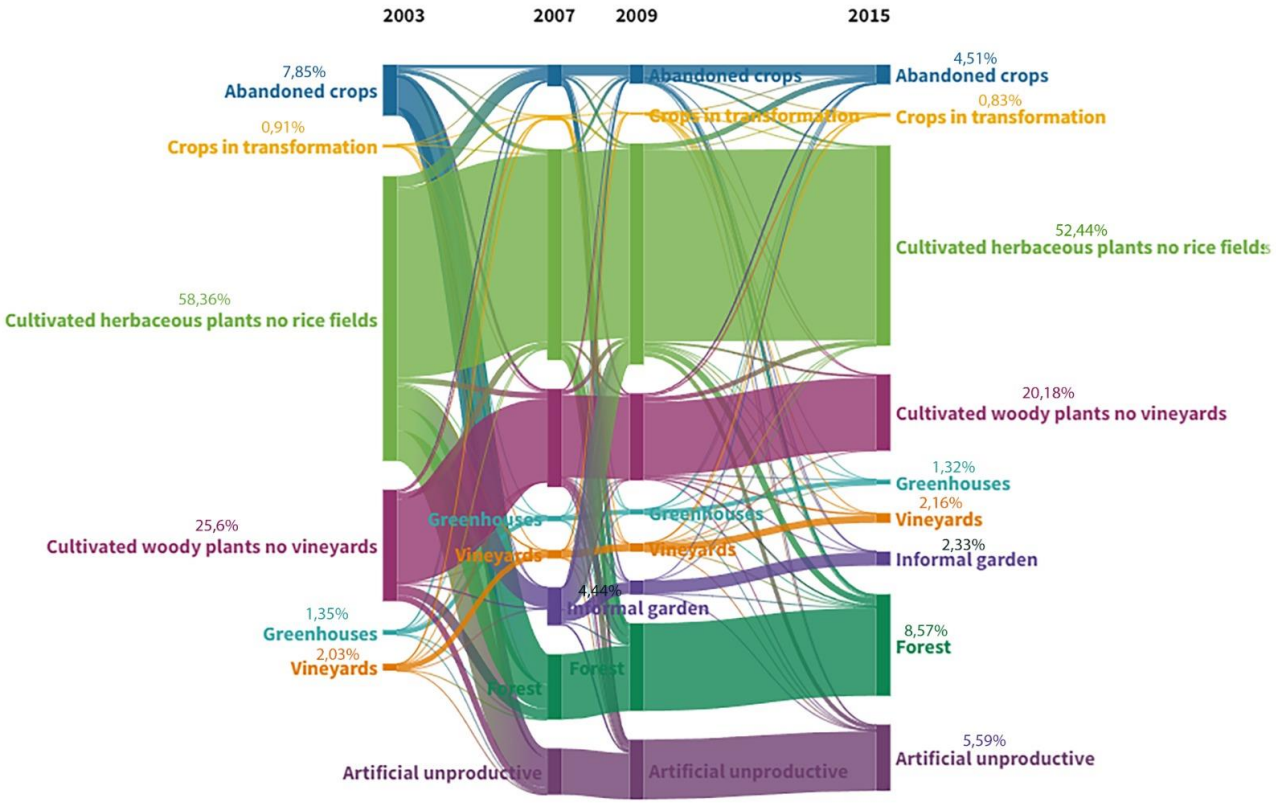
Appendixes.

A. Category “Others”disaggregated



B. Interview guideline

Do you are aware of the loss of agriculture in the AMB? What do you think about that?

What kind of crops are grown in the Barcelona metropolitan area today?

Which types of crops have been lost the most and which have been preserved the most? Do you know what the main factors are that explain this?

Respect to agriculture that has been lost, it has involved more small plots of land, medium-sized or large?

We have seen that a considerable part of the loss of agricultural land has gone to forest land.What are the processes inherent in the loss of agricultural land to forest land?

Do you know the main drivers of land use change from agriculture to built-up areas? Do you think the change is exclusively linked to population growth or are there other mechanisms, for example speculative mechanisms?

How do you feel about current regulation (at national, regional and local level) related to urban and peri-urban agriculture? Do you think that current regulations are an obstacle for urban and peri-urban agriculture?

Looking at the 2003-2015 trend, it seems that the net loss of peri-urban and urban agriculture has stabilised. Do you think the period 2015-2022 followed this trend? Did and will the covid-19 pandemic and the current energy crisis influence this process?

What happened in the period 2003-2007 in terms of agricultural loss, period that experienced the highest rate of agricultural loss among the periods analysed. Any thought about this high rate of loss in agriculture? Do you think the real estate bubble (1996-2007) could explain this difference?

Is the phenomenon of informal gardens relevant to urban and peri-urban agriculture? Do you think that in general it is a type of agriculture associated with spaces not formally defined as 'agricultural land'?

There was a strong loss of horta familiar/informal until 2009 and a recovery from 2009 to 2015 (this recovery is mainly seen in the horticultural zone of Gava). Any thoughts about this trend? Do you think this recovery was an effect of the economic crisis of 2008? And from 2015 to 2022 do you think the trend will continue increasing slightly or is there a reversal again?

How are informal garden perceived by citizens, professional farmers and institutions? Why?

Do you know of any plans explicitly reduce the informal garden in order to devote the land to other uses deemed more appropriate?

What do you think can be done (regulations, initiatives, funding) at the city (but also regional and national) level to help (no longer lose) and strengthen the activities, processes and productions related to urban and peri-urban agriculture? And who do you think could be responsible for (no longer lose) and strengthening urban and peri-urban agriculture? Local administrations, regional, organizations, citizens, etcc. etc..