Vacant lands on French Mediterranean coastlines: Inventory, agricultural opportunities, and prospective scenarios

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1. Introduction

1.1 MedCoast urban background

Mediterranean coastlines (hereafter MedCoast) have been experiencing strong, rapid urbanization during the last decades, partly due to demographic growth (from 90 million in 1950 to 290 million in 2005), and also related to urban and tourism development (UNEP, 2012; Burak et al., 2004). The Mediterranean area is also considered as a biodiversity hotspot (Cuttelod et al., 2008). Given the fact that an irreversible decrease in this resource is expected in response to climate change (see IPCC, 2014; Malcolm et al., 2006), attention has to be paid to the growing areas of artificialized lands (France Stratégie, 2019), which represent an additional threat to natural resources (Narducci et al. 2019, Garcia-Ayllon 2018b, Holon et al., 2015). While around 40% of the MedCoast area is estimated to be artificialized in terms of land cover (UNEP, 2017), a major part of this is due to scattered residential urbanization. Urban sprawl has progressively increased in all European countries since the 1970s (Lagarias and Sayas, 2019; Salvati et al. 2013; Catalán et al., 2008; Kasanko et al., 2006), mainly at the expense of agricultural areas, and has lead to fragmentation of the rural mosaic (e.g. Debolini et al., 2018; Aksoy et al., 2017; Salvati et al., 2012). In France, despite protective legislation for coastlines (Le Berre et al. 2016) and urban densification policies (to preserve both traditional city centers and natural lands), wide urban sprawl has developed (Pumain, 2004), and this process is continuing (Melot et al., 2018).

Nowadays, MedCoast areas are under pressure from different conflicting interests. This pressure is the main cause of land use competition, leading to land price rises and even to the subsequent exclusion of some social categories from land access (Garcìa-Ayllòn, 2015; Coskun Hepcan, 2013). This competition has always favored of urban residential use, because of the differential soil rent (Dachary-Bernard et al., 2011). For these reasons, MedCoast municipalities have progressively become more dependent on residential taxes (Grandclement and Boulay, 2016), with local policy makers increasingly interested in urban residential development (Membrado et al., 2016; Chabert, 2016). Urbanization is mainly taking place on natural or agricultural spaces, even though there is usually an officially-proclaimed intention to maintain them (Colsaet et al. 2018; Prevost and Robert 2016; Padeiro, 2016; Abrantes et al., 2015). Such an urban residential development implies an economic specialization, mainly in the local services sector, which can destabilize the local economy if there is a disruption of the tourist, retiree or commuter flux (Davezies, 2009; Spilanis, 2009). We have therefore studied alternative territorial development with agriculture. It has been recognized that agriculture is a lever of local sustainable development which can facilitate the reinjection of productive activities on the coast (Ragkos et al., 2016; Blanford, 2011; Benoit and Comeau, 2005), give local employment (Nicholls et al., 2020), provide ecosystem services (Ricart et al., 2019), and also improve local food security (Filippini et al., 2018; Zezza and Tasciotti, 2010). Moreover, agriculture has been identified as one of the key sector for preserving and restoring European natural capital on the recently released documents for a European Green deal and the Biodiversity strategy for 2030. The European strategy underline the importance of agricultural sustainable practice for improving environmental and climate performance and the need to support rural development to help rural areas to harness opportunities in the circular and bio-economy through "farm to fork" initiatives (EC, 2019; EC, 2020). Thus, there is a growing interest in the remaining places where agriculture is possible, and the type of agricultural projects that could be developed in coastline areas under pressure.

1.2 Vacant lands inventory and valorization

In the literature, three different definitions of vacant lands can be found. They can be unbuilt constructible lands with potential for housing construction and urban densification (Saiz, 2010). Secondly, they can also be defined as unbuilt lands (constructible or not) currently unused or abandoned (e.g. brownfields, transportation-related sites), located in urban areas (mainly in the form of small residual plots) with a low value on the property markets (Gedal and Ellen 2018). Since the 2000s, studies in this field have shown how cities deal with vacant lands through different urban renewal projects (Kim et al., 2018; Németh and Langhorst, 2014), including transforming vacant lands into productive ones (e.g. Sanches and Mesquita Pellegrino, 2016; Kim et al., 2015). This means a valorization of vacant lands in terms of redevelopment (e.g. for urban gardening or urban agriculture) to set up urban renewal and thus with impacts expected on the limitation of urban sprawl, and also to avoid city decline (Goldstein et al., 2001). Thirdly, studies focusing on agricultural land suitability analysis usually undertake a vacant lands inventory in order to assess the possible development of urban farming (Mcdougall and al. 2020; McClintock et al., 2013; Erickson et al., 2013). For the majority of them, the starting point is however the analysis of soil quality data (rather than land-use data) for specific crops, and the lands are located within agricultural zones (e.g. Seyedmohammadia et al., 2019 - study on barley cultivation).

In this paper, we lie at the intersection of the three definitions and we propose then a specific one. With the term "vacant lands", we mean all the lands not currently occupied by urbanization and which do not need specific treatment to be developed, such as demolition or decontamination. They need to be exploitable according to geographical (e.g. land-use), physical (e.g. excluding steep slopes), and some regulatory criteria (e.g. excluding military areas). They thus include uncultivated lands, natural and forest areas, and urban wastelands. We considered vacant lands in the broad sense of available lands, without taking into account temporary constraints of non-availability (e.g. local planning documents, land ownership etc.). The field of study developed at a very local scale in an urban context was thus enlarged to go beyond the urban areas, and the concept of vacant lands was applied to an extended territory. In this context and in order to improve sustainable planning and development of the MedCoast, we attempted to answer the following main research questions: what are the possibilities for vacant land valorization other than by residential use, and which territorial scenarios of agricultural development could be explored, depending on the agricultural opportunities of existing vacant lands? We considered the term agricultural opportunities as the type and level of agricultural production possibly suitable for vacant lands, according to Erickson et al. (2013). These questions were investigated in two coastal areas in southern France, both characterized by a rising demographic pressure, a strong residential- and tourism-based economy, and an environmental heritage.

Land use scenarios have been widely applied to help decision makers in anticipating the future. In methodological terms, land use transformation models have mainly been employed for scenario simulations, using past land use transitions to study the location and/or the nature of future changes (Vannier and al. 2019; Sinha and Griffith, 2019; Lee and al. 2018; Loubier and al., 2017; Houet and al., 2016; Gutiérrez Angonese and Grau, 2014). Other scenarios have been built from a geostatistical approach which gives an important place to landscape spatial patterns (e.g. García-Ayllon, 2018). In this field, some pro-agricultural scenarios have been developed (e.g. Rega and al. 2019; Rounsevell and al., 2006; Iverson Nassauer and Cori 2004; Abrantes and al., 2017) to study alternatives to urban and periurban dynamic continuation. Estimations of the urban agricultural potential of cities to provide a local food supply have also been developed (Mcdougall et al., 2020; McClintock, 2013), deepening existing works on the agricultural potential of vacant lands (Sanches and Mesquita Pellegrino, 2016; Erickson et al., 2013). In line with these previous works, our study assessed vacant lands from a GIS-based inventory and a spatial and expert analysis of their suitability for agricultural production. In addition, spatialized normative scenarios for sustainable agriculture were built, and include a co-constructive approach with stakeholders and researchers. They studied both which agricultural system types could arise in the future and what spatial implementation of the scenario could be possible. Territorial scenarios were quantified and mapped, and their impacts were measured through socio-economic indexes.

2. Study areas

The two areas studied are located in the South of France, in the Var department.

The first is the inter-municipality of Toulon Provence Méditerranée (hereafter TPM). This territory includes twelve municipalities and had about 431 000 inhabitants in 2015 (INSEE, 2015). It is the third largest metropolitan area of the region. TPM has had a huge increase in its urban areas, which doubled in the 40 years between 1970 and 2010 (Syndicat Mixte Provence Méditerranée, 2009). Today, much of the territory is covered by urban areas (40% in 2011), and the urban sprawl - although slowing down - is still ongoing, at a rate of +3.8% (512.6 ha) between 2003 and 2011 (Tab.1). Most of this urban sprawl is at the expense of agricultural areas (70%, or 359 ha, of new artificialized spaces in 2011 were agricultural until between 2003 and 2011), and as a result, agricultural land is continually shrinking and becoming more fragmented. Nevertheless, despite the size of its urban areas and their growth, TPM is attractive to tourists with 84 500 additional people in 2011 (Syndicat Mixte Provence Méditerranée, 2009). At present, some areas are protected (former saline zones, wetlands, classified woodlands) and the coastline is attractive, even if a part is reserved for military activities. Therefore, this case study is an example of a metropolitan littoral territory, which must strike a balance between hosting or housing its tourists and the permanent population, and preserving its natural and agricultural areas.

The second area is the inter-municipality called “Golfe de Saint-Tropez”, the Saint-Tropez Gulf. Located to the east of TPM, this territory also includes twelve municipalities but had only 57600 inhabitants in 2015 (INSEE 2015). Nevertheless, even if the urban areas represent only 17% of the territory, the urban sprawl development has been greater than that of TPM, with an average annual growth rate of +0.97% (+0.47% compared to TPM). Between 2003 and 2014, 743 ha of new urban areas appeared. This urban growth could be explained in part by the high attractiveness of this territory for tourists. In the peak season, the population of the inter-municipality is multiplied by four (Communauté de communes du Golfe de Saint Tropez, 2019). The Gulf of Saint-Tropez is a highly popular destination, with its 70 km of coastline, its large forested areas (the Maures massif) and its typical local agriculture. Natural areas make up more than 70% of the territory, including agricultural areas which are dominated by vineyards (62%). Nevertheless, these areas are being increasingly gained by urbanization. Our case studies are therefore good examples of a touristic littoral territory with a high residential development rate, which must be controlled as there is a significant risk of landscape degradation. Both case study areas have suffered over recent decades from an increasing land consumption due to the progressive shift of the local economy toward the tourism and residential accommodation sectors.

The inter-municipality level was chosen because it is currently the most relevant in terms of planning, linking municipal and regional scales of governance, and it is where the agricultural orientations are defined. Moreover, it is an intermediate level between the micro scale of the municipality and the bigger department scale. The two case study areas were also chosen because of the residual presence of productive agriculture. Table 1 shows the main land use characteristics of the areas studied, and Fig. 1 shows their location.

Indicators	**TPM**	**GST**
Area of the zones studied	37 224 ha	43 395 ha
Urban areas in 2011/2014	40%	17%
Agricultural areas 2011/2014	16.7%	10%
New urban areas between 2003 and 2011/2014	+ 3.8 %	+ 11.2%
Average annual growth rate of urban areas	+ 0.47 %	+ 0.97 %
Average annual area of new urbanization	64 ha	67.5 ha
New urban areas which were agricultural in 2003	70%	26%

Tab. 1: Main characteristics of the two case study areas: Toulon Provence Metropole (TPM) andGolfe de Saint Tropez (GST). The years of the land use data are not the same for our two case studies. The TPM territory has land use data for the years 2003 to 2011, while for the GST intermunicipality territory the data concerns the years 2003 to 2014. To be able to compare the evolutions of the two territories, we used average annual growth rates.

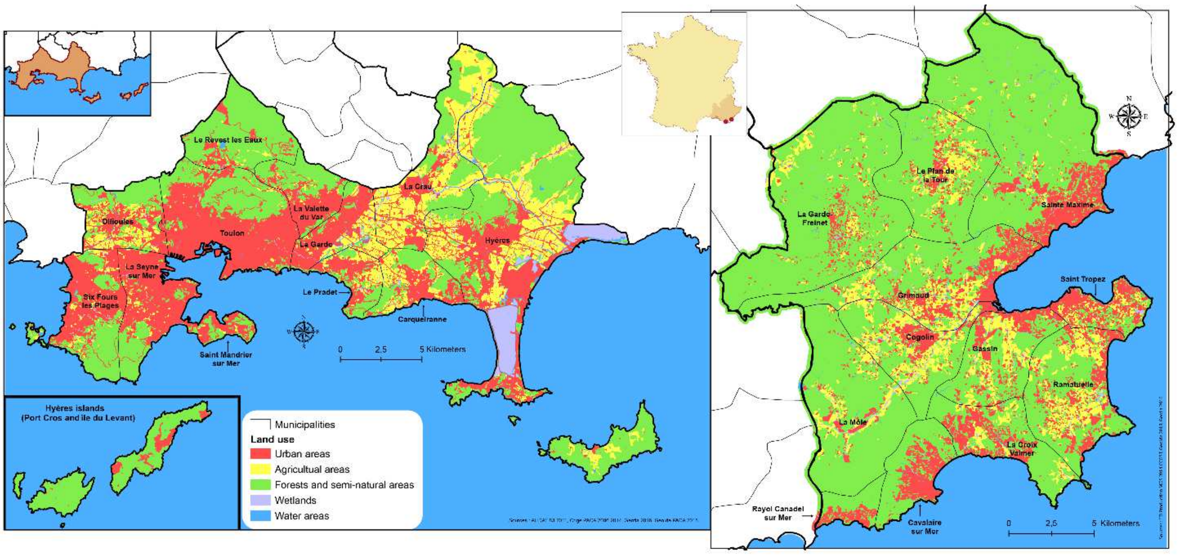

Fig.1: Locations of the two case studies.

3. Material and methods

In this work, a GIS-based inventory of vacant lands was carried out at parcel scale over a vast territory. Classification tools based on a scoring analysis and on a multivariate statistical analysis (AHC) were then applied, in order to prioritize the interest of lands for an agricultural valorization according to a set of geographical, morphological, and regulatory criteria, which defined agricultural opportunities. This methodological part is in line with the work of Sanches and Mesquita Pellegrino (2016), and Erickson and al. (2013). Looking ahead, prospective scenarios were then built (Pérez-Soba and Maas, 2015; Börjeson and al., 2006) to show decision makers potential pathways for alternatives to residential use for future territorial developments. Considering the high urbanization threat to agricultural lands, confirmed by trend scenarios (e.g. Rounsevell et al., 2006), normative scenarios concerning sustainable planning projects were favoured. They are built in a combined quantitative and qualitative approach. A spatial analysis method operationalized the hypothesis of agricultural expansion on the vacant lands of the two case studies. An expert approach was employed to define future agricultural systems. The method was aligned with spatial prospective approaches (Gourmelon and al. 2012; Casanova and Helle, 2012) and integrate a concerted process between researchers, local stakeholders, and students (Vannier and al. 2019; Abrantes and al., 2017, Maestripieri and al. 2015; Iverson Nassauer and Cori, 2004; Loubier and al., 2017). Such an approach fosters creativeness within the limits of possible new planning strategies (e.g. depending on the suitability of vacant lands).

GIS queries based on a set of parcel scale geographical data were carried out first to inventory vacant lands (Fig 2; Step1). The starting point was the identification of all the existing whole or part(s) of parcels potentially available in purely land use terms (corresponding to the non-urban areas). Then, all the possible factors excluding the use of these lands for agriculture were considered, such as morphological factors (e.g. slope) or regulatory aspects (e.g. environmentally protected areas, military areas). The existing regulatory measures in local planning documents were deliberately not taken into account, since the aim of the work was to provide alternatives to current planning, and also because the documents can be changed over time. For example, at the municipal scale planning is based on a document which can be revised three years after its initial approval. At the inter-municipal scale, land use planning is based on a document revisable every six years. Through these GIS queries, we obtained an overall inventory of vacant lands.

The agricultural opportunities for the vacant lands were estimated next (Fig 2; Step2). For this, we made two classifications: the first provides a scoring of vacant land parcels in order to evaluate their agricultural potential; the second, based on an Ascending Hierarchical Classification (AHC), clusters profiles of parcels in terms of their spatial characteristics. The results give indications as to the spectrum of possible future agricultural developments in the territories.

In order to explore these possibilities for the future, we used the results of the two classifications in a third step to build possible future territorial scenarios, fitting in sustainable agricultural development. The scenarios, one for each case study (Fig 2; Step 3), are proposed as examples of the possible applications of this work for policy makers.

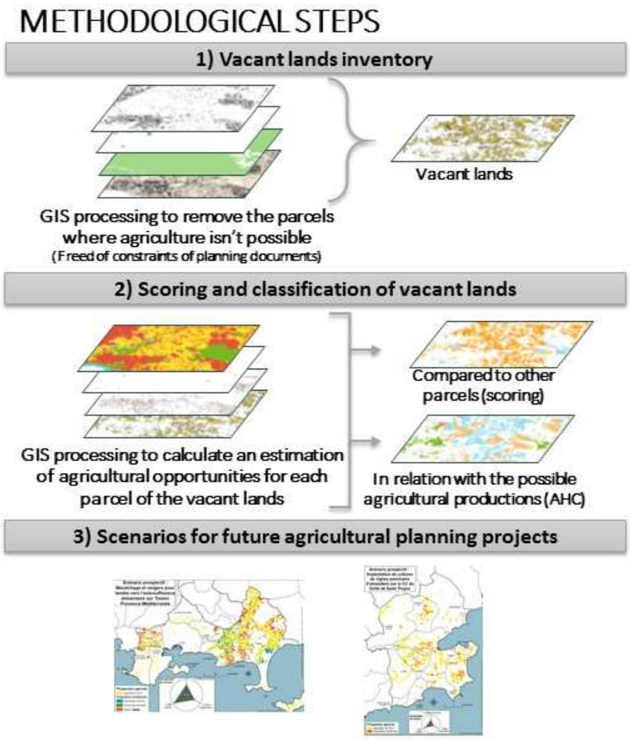

Fig. 2 The overall methodological workflow. Each step is detailed in the following sections.

3.1 Datasets

3.1.1 Cadaster dataset

The cadaster, or land registry, dataset gives an annual overview of property ownership. This data is used by the French government services for fiscal purposes. It therefore includes full and precise information concerning land ownership for unbuilt or built property (DGALN-AD3 - CEREMA Nord-Picardie, 2017). We particularly focused on the parcel map and on data concerning landowners and householders (e.g. number of owners, public or private status), land use, and building types (e.g. flat, house, industrial or commercial buildings).

The intersections of the data provide detailed geospatial information on urbanization processes (ownership changes, construction pace etc.).

3.1.2 Land use and planning datasets

In addition to the cadaster dataset - the reference data for the study - other geographical datasets were included in the analysis to complete the information about land use, topography, agricultural systems, and planning. Table 2 shows the complete dataset list.

Name of data	Source	Date	Metadata complement
Digital Terrain Model	IGN	2008	
Land use of the PACA region	CRIGE PACA	2006 2014	Scale of interpretation 1:25 000 to 1:50 000
Land use	AUDAT Var	2011[1]	Scale of interpretation 1:1 500 to 1:3 000
Land use in the area of the Gulf of St-Tropez	TTI Production via CRIGE PACA	2014	Scale of interpretation 1:1 500 to 1:3 000
Irrigable perimeters of the Canal of Provence Company	Canal of Provence Company via CRIGE PACA	2016	
Others irrigable perimeters	Base Hydra of the Regional Agricultural Chamber	2014	
Environmental zoning	Geoide PACA	2018	It contains the Decrees for the Protection of Biotopes, wetlands, Sensitive Natural Areas and some Conservatory of Natural Spaces estates.
Military areas	Open Street Map	2018	
Installations Classified for the Protection of the Environment (ICPE)	Geoide PACA	2018	Buildings with potentially negative environmental and/or human health risk or impact

[1] Access to the 2014 version was denied to our research group because the dataset producer considered that the information contained in the dataset was too sensitive in policy terms.

Areas submitted to a clearance authorization	DDTM 83	2017	In these areas authorization must be requested before deforestation.
Roads	Open Street Map	2018	The roads were extracted from OSM and processed with the Grass tools (cleaning, reconnection).
Local markets	New layer	2018	The market locations were found on different web sites, and then compiled and put in a vector format.
Cooperatives	New layer	2018	The cooperative locations were found on the web site “coopdefrance”, and then put in a vector format.

Table 2: List of datasets used for vacant land identification and classification.

3.2 Inventory of vacant lands suitable for agricultural use

As agriculture cannot be developed on all vacant lands, we analyzed vacant land parcel characteristics based on a set of exclusion constraints corresponding to major obstacles to agricultural valorization. Six main exclusion constraints were selected. Cultivated lands were included, to assess (and show to decision makers) the interest of maintaining them for agricultural use. Constraints were defined by the researchers and shared with experts from the regional and local public planning institutions specialized either in agricultural, rural, or urban land management, or in overall intermunicipality planning. The exclusion constraints identified were: (1) slope > 35%, (2) inclusion in a military area, (3) inclusion in a protected environment area, (4) intersection with an ICPE (see Figure 2), (5) intersection with built-up areas, streets, or cemeteries, and (6) parcel or parcel aggregation dimension < 200 m^2. Figure 3 summarizes the exclusion factors. Once these exclusion constraints were defined, the spatial dataset was processed to remove the vacant land parcels where agriculture is not possible. An additional GIS analysis was done to remove residual errors, in particular those related to the morphology of parcels. In particular, we aimed to eliminate plots with a very slender shape, unsuitable for agriculture, which in the majority of cases correspond to residual portions of private roads (public roads are not mapped in the cadaster plan). To do this, a compactness coefficient (first given by Gravelius and often used in hydrology studies) was applied, and calculated as follows: $K = 0.28 * (P/\sqrt{A})$, where P is the perimeter of the plot given in meters and A the surface area of the plot given in m^2. The closer the K value is to 1, the closer its shape is to a circle. The higher it is than 1, the longer and more slender its shape is. In accordance with empirical test validations (including comparisons with orthophotos), a threshold of 2.2 was applied to remove these linear plots.

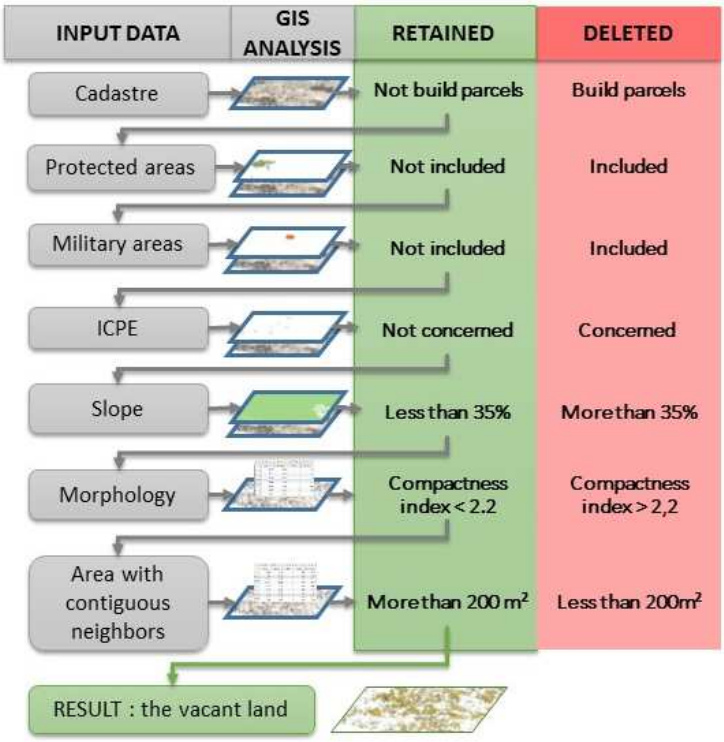

Fig.3: Exclusion constraints for agricultural valorization of vacant lands

3.3 Scoring and classification of vacant lands for agricultural opportunities estimation

In order to prioritize vacant lands in terms of their opportunities for agricultural valorization, we considered a set of geographical, morphological, and regulatory criteria. When the criteria results are not significant, agriculture can still be developed but its potential is reduced (requiring, for example, parcel remodeling or adapting farming practices). As above, we used an expert-based method to define our nine criteria, which were assessed through GIS at parcel scale (Fig 4).

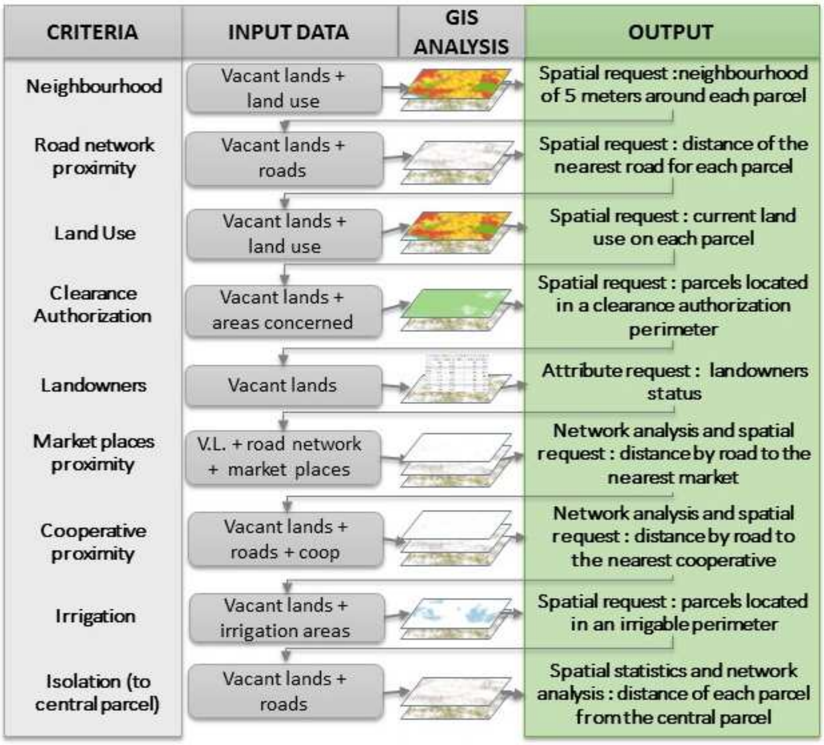

Fig.4: Spatial analysis methods for criteria calculation

Each criterion category concerning vacant land spatial distribution characteristics, land use, and parcel facilities for an agricultural activity, refers to a quantitative value or a qualitative modality, which was then converted into a score. In order to estimate the level of agricultural opportunities for a vacant land parcel, a value was assigned for each criterion, which all had the same weight: values range from 1, the least suitable lands, to 3, the most suitable. For each parcel, the allocation of a quantitative value or a qualitative modality to a score value was respectively determined by the classes defined in the statistical distribution (i.e. classes of equal intervals) and by an expert decision.

Table 3 summarizes the list of criteria selected and their values. The values were then totaled for each parcel to obtain a global score for parcel agricultural opportunities. Results were next converted into a center-reduced standardization depending on the standard deviations, to highlight parcels with the highest potential (thus, values between the two case studies refer to different orders of magnitude, and are not directly comparable).

Criteria \ Score	1	2	3
Current Land use	Urban area only	Natural area/wetlands	Agricultural area
Neighborhood land use	Urban area only	Natural area/wetlands but no agriculture	Agricultural area
Road proximity	More than 100m	50m to 100m	Less than 50m
Agricultural market proximity	Isochron > 20min	10min to 20min	Less than 10min
Cooperative proximity	More than 20min	10min to 20min	Less than 10min
Isolation (distance from the	More than 20km	10km to 20km	Less than 10km

central parcel)			
Clearance authorization	Submitted	/	Not submitted
Irrigation possibility	No	/	Yes
Landowners' structure	Multi-private landowners	Mono-private landowner	Public landowners

Table 3: Scoring parameters and settings for the estimation of parcel agricultural opportunities

In parallel, using an Ascending Hierarchical Classification (AHC), parcels were clustered into different classes of agricultural opportunities. The classification was based on the same criteria as those defined for Fig.4 (without taking into account the scoring step). Thus, this classification provides an overview of the agricultural production possible in each cluster.

Finally, we examined the possible threat which urban and suburban fronts represent for the vacant lands which offer the highest opportunities for an agricultural valorization. We carried out a proximity analysis of the newly artificialized spaces compared to the vacant lands with a score higher than 1. This analysis intends to draw the attention of decision makers to the urgent need to protect prime farmlands.

3.4 Territorial scenario building for agricultural development

In order to show the possible usefulness of this study for policy makers, we built two possible future agricultural development scenarios, one for each case study. The two criteria that we applied in order to build these scenarios were (1) the main agricultural system already existing in the area (existing crops, productive orientation, distribution chain already active, etc.), and (2) the environmental sustainability of the whole system. The links between the current agricultural system in the case study areas and the future possibilities explored in the normative scenarios are detailed in Table 4 below.

	Main economic sector (% of firms in the sector in 2015, INSEE)	**Main agricultural production (% of areas farmed in 2010, SCOT)**	**Main distribution channel**	**Other agricultural production**	**Weakness of the agricultural system**	**Main local agricultural policy**	**Scenario for a sustainable local agriculture**
GST agricultural system	Trade, transport and services: 73% of firms (Agriculture: 2.7% of firms)	Vineyards: 82% Quality labels	National / international export	Olive growing Market gardening Forestry	Export dependency Competition between vineyards and small local farming Fewer farmers Deficiency of irrigation system	Agricultural landscape conservation Short supply chains	Planting of vineyards and almond orchards to maintain a high added value activity
TPM agricultural system	Public administration, education, social work: 66% of firms (Agriculture: 0.2% of firms)	Vineyards: 46% Market gardening: 11% Horticulture: 11% Quality labels -Irrigation	National / international export (1st flower growing area of France)	Fig cultivation	Decrease of farmers Housing affordability for farmers	Agricultural land conservation and spatial continuum Support to flower growing industry	Development of market gardening and orchards to reach foodstuff self-sufficiency Short supply chains and organic production

Source: French national public statistics (Insee, Agreste) and intermunicipal planning documents

Table 4: Relationships between the current agricultural system and the prospective agricultural scenarios proposed

For instance, we selected a possible agricultural system which involved the greatest preservation of the forest cover and the optimum utilization of the water resource. The two scenarios were built in collaboration with a group of students and researchers, and with the preliminary advice of local stakeholders. Researchers then defined the normative hypotheses of the prospective scenarios which provide for sustainable agricultural development. Then, using collaborative GIS tools, students and researchers detailed and spatialized scenarios for each case study during workshops.
Spatial analysis methods were applied to the vacant land inventory in order to select the most suitable lands for the scenario's agricultural project. Then the impacts of the scenarios in terms of territorial development were estimated for the three following criteria: agricultural employment generated, added economic resources, and agricultural cover extension. These criteria were evaluated using national statistics for agricultural prices and also agricultural statistics for job increase evaluation (Table 5). In particular, the average number of jobs per hectare by crop type and the average added value per hectare by crop type (in France) were used. Then the new crop type distribution and the new agricultural area added (from current vacant lands) in the scenarios were converted into agricultural jobs and added economic resources for the territory.

Data	Source	Date	Metadata complement
Annual added values by crop production in France	INSEE,	2017	Estimated accounts of agriculture, base 2010
Areas of different crop production in France	AGRESTE	2016-2017	Annual agricultural statistics 2016-2017 Published in 2019
Dominant crop on the property, cultivated area, farm size, number of employees, farm location	RGA AGRESTE	2010	Farm scale
MOS GST	TTI production	2014	Scale of interpretation 1:1 500 to 1:3 000
MOS TPM	AUDAT83	2011	Scale of interpretation 1:1 500 to 1:3 000

Table 5. List of datasets used for the estimation of the socio-economic impacts of the scenarios

4. Results

4.1 A reserve of vacant lands with unequal opportunities for agricultural valorization

Despite the on-going urbanization process and the increase in lands taken over, the two coastal areas have large amounts of vacant land, almost 8800 ha for TPM and 16100 ha for GST (Table 6 and Figure 5). In TPM, they represent 39% of non-urban areas and 23.5% of the intermunicipality area, while in GST, they represent 48% of non-urban areas and 37% of the intermunicipality area.

The topography constraints, the presence of buildings on parcels disconnected from urban areas, and the presence of strictly-protected natural lands and forests explain why only half of the vacant lands have interesting agricultural opportunities.

The nine criteria classified from 1 to 3 were totaled for each parcel, with the minimum possible score being 9 and the maximum possible score 27. Thus we considered that the parcels with an absolute score above 18 (i.e. the median) present a real potential for agriculture. In TPM, these parcels correspond to 5398 ha, i.e. 61.6% of the total amount of vacant lands and 14.5% of the intermunicipality area. For GST they represent 5419 ha, i.e. 33.6% of the total amount of vacant lands and 12.5% of the intermunicipality area.

In order to prioritize the agricultural interest of the vacant lands in each territory and to compare the two case studies, we standardized the parcel scores. The results are shown in Table 6.

		TPM (ha)		**GST (ha)**	
Urban areas		14144		7783	
Non-urban area		22841		33655	
Total vacant lands		8764		16124	
Vacant lands for each score		**(ha)**	**(%)**	**(ha)**	**(%)**
	+2 to +3	14	0.2	177	1.1
	+1 to +2	1569	17.9	2424	15.0
	0 to +1	2280	26.0	5366	33.3
	-1 to 0	2274	26.0	3313	20.5
	-2 to -1	2167	24.7	4843	30.0
	-3 to -2	459	5.2	0.4	0.0
	-4 to -3	2	0.0	0.0	0.0

Table 6: Vacant lands - potential agricultural areas by score class. In red, the plots with high agricultural opportunities; in blue, the plots with low agricultural opportunities; in yellow, the plots with medium agricultural opportunities.

The vacant lands include areas impacted by various planning projects or environmentally-related authorization requirements (weak, because not stable over time), concerning natural and forest lands, as well as brownfields and wastelands. This means that not all vacant lands can be considered as being available for agriculture. Figure 5 shows vacant land areas with their agricultural opportunities scores.

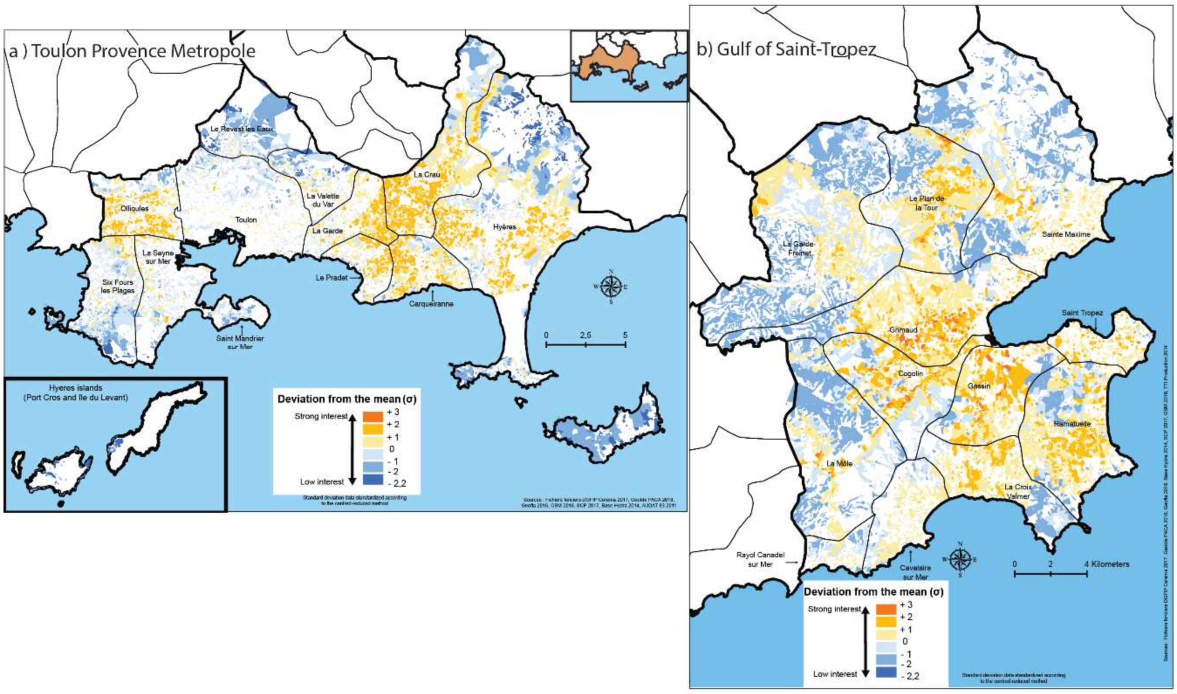

Figure 5: Location of vacant lands and their agricultural opportunities scores

The results show that almost half of the vacant lands have a significant or very significant potential for agriculture, according to our geographical, morphological, and regulatory criteria. Vacant lands with a score higher than 0 (i.e. the average) represent 3863 ha in GST and 7967 ha in TPM. In TPM, they are concentrated in two main zones: one municipality in the western part of the territory (Ollioules) and one wider area in the eastern part of the territory, extending over five municipalities and mainly corresponding to coastal plains drained by the Gapeau River. In GST, they are located in the inland part of the territory, away from the artificialized coastal line and not including the Maures mountain ranges. They are mainly concentrated on plains (of the Grimaud municipality, in particular), drained by little coastal rivers (e.g. La Giscle) and their tributaries. It can also be noted that some municipalities have very few vacant land areas with agricultural interest, in particular in TPM due to land already taken by urban expansion (e.g. Six-Fours-les-Plages, Sanary-sur-Mer, Saint-Mandrier, Toulon).

4.2 Artificialization threat to vacant lands

Combining the vacant land agricultural opportunities scores with data concerning new artificialization from between 2006 and 2014 (Crige data), we could better estimate the proximity – and thereafter the threat – of urban and suburban fronts. To do this, we analyzed the proximity of the newly artificialized spaces (urban extension or urban densification) to the vacant lands with a score higher than 1. These parcels represent 1583 ha in TPM and 2601 ha in GST. About 60% of the areas newly artificialized between 2006 and 2014 are located within 5 meters of the vacant land parcels with the highest scores. For a distance of 200 m, the results exceed 70% in TPM and reach nearly 85% in GST (Table 7). Figure 6, based on an aerial photograph, spatially illustrates the threat of new urbanization to the vacant lands with the highest potential.

	% of high score vacant lands in the buffer/ total high score vacant lands		**% of vacant lands in the buffer /total vacant lands**	
Buffer distance from newly artificialized spaces	TPM	GST	TPM	GST
5m	58.3%	62.5%	1.9 %	2.1%
50m	67.3%	77.4%	3 %	3.6%
100m	68.9%	81.9%	4.6%	5.4%
200m	72.8%	84.8%	7.6%	9.6%

Tab. 7: Proximity between new urban spaces and high score vacant lands

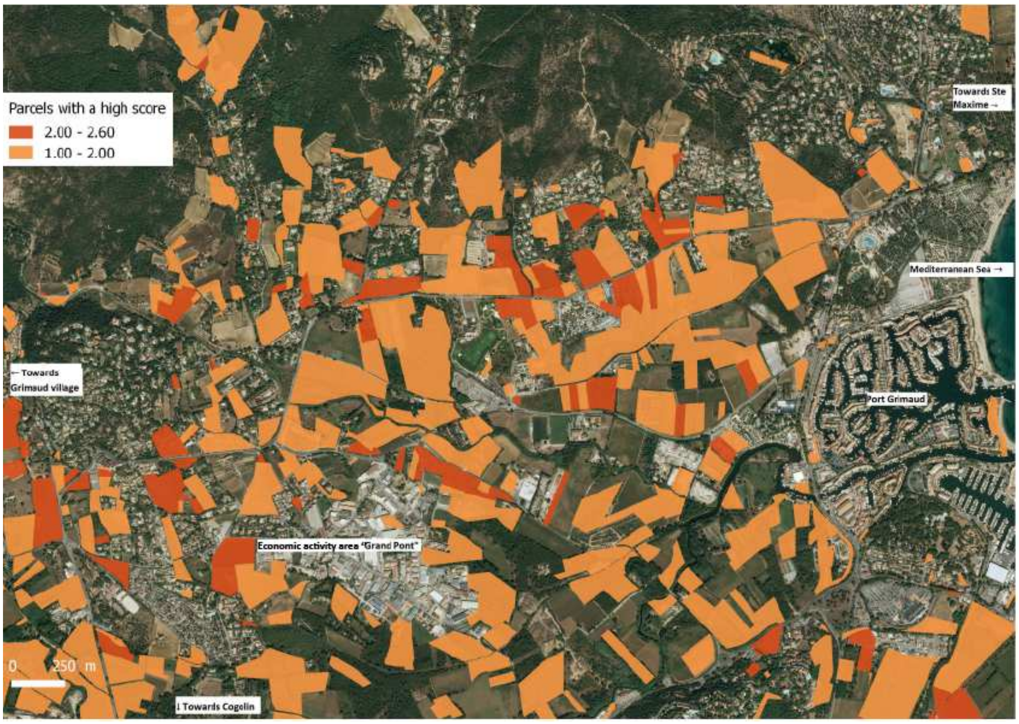

Fig 6: Urban and suburban threat to the high-score vacant lands on the plain of the Grimaud municipality (GST)

Figure 6 focuses on the Grimaud plain, located in the GST territory. It highlights the proximity between urban spaces (mostly for residential use) and parcels with high scores for agricultural opportunities. The Grimaud plain was originally an agricultural area, which is why it has a concentration of parcels with good scores. However, urban spread has been progressively developing on this plain, creating an urban continuum between the different municipalities. The villages of

Grimaud (center-west) and Cogolin (south-west) are contiguous. There are a number of residential subdivisions making an almost continuous urban line between Grimaud (west-center) and Sainte-Maxime (north-east). Moreover, a large economic activity area is located in the center of this agricultural plain.

4.3 Varied agricultural opportunities for vacant lands

In order to deepen the analysis of the vacant lands, we carried out a classification (AHC) of vacant land parcels, based on the criteria previously selected (Fig. 4). Results for the agricultural opportunities of parcels as given by the AHC are summarized in Fig. 7.

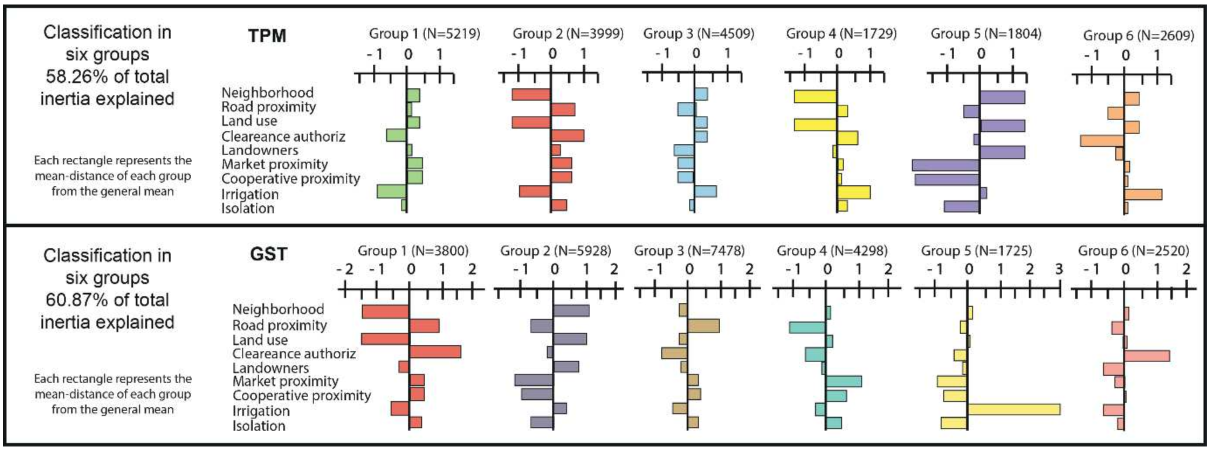

Fig. 7: Results of the AHC for the two case studies

The two AHC classifications identified six vacant land classes.

Two classes (represented in red and violet) have a similar profile for the two territories. The red class characterizes vacant lands located in an urban context (very small parcel size) and without irrigation system access. The violet class characterizes vacant lands located in a rural context (mainly natural lands) which are distant from inhabited areas and from points of sale (e.g. farm cooperative, market place). Two classes show that there are some specific local characteristics: class 6 describes very isolated vacant lands in TPM, while class 5 in GST describes all the vacant lands with the possibility of an irrigation system, which is a differentiating criterion (infrequently available in this territory). Other classes have more heterogeneous profiles in terms of types of agricultural opportunities.

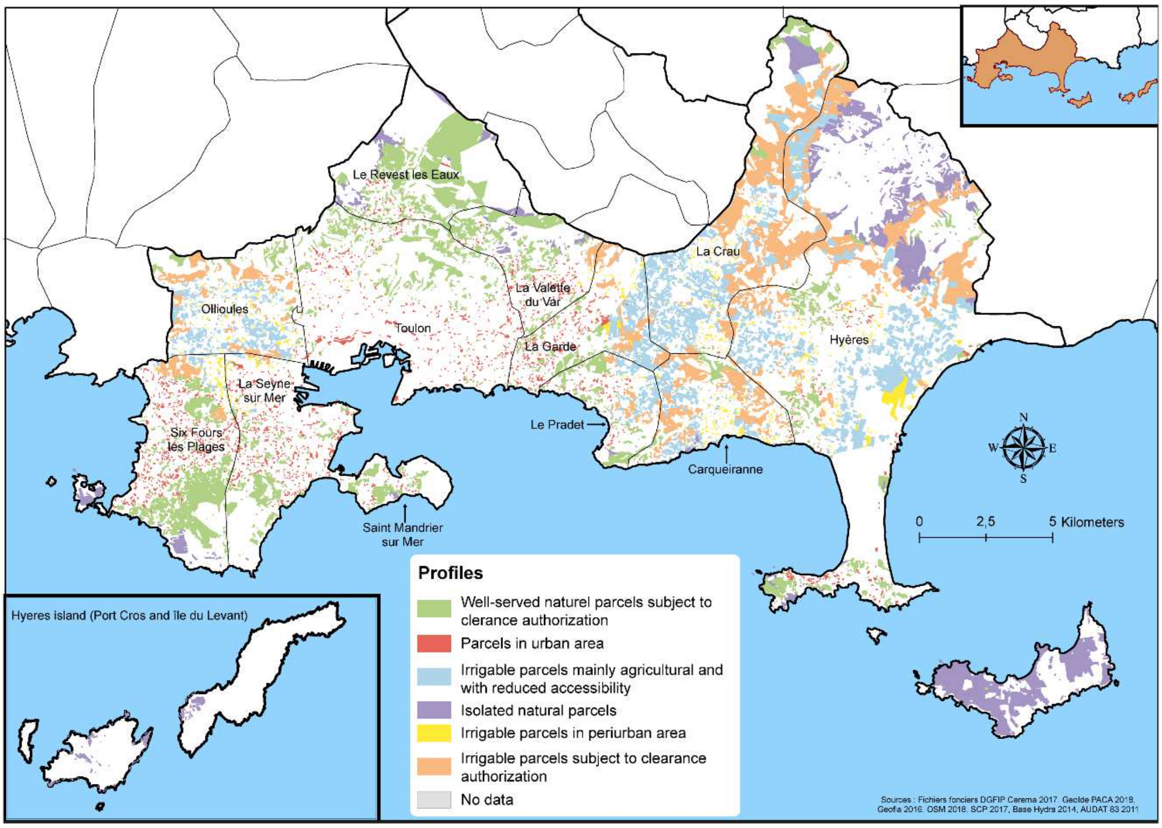

Fig 8: Classes of agricultural opportunities for vacant lands in TPM. The colours used in the key are the same as those employed in Table 8.

The distribution of the red class, the parcels concerned by urban constraints (e.g. neighbors, road proximity, current land use) shows that these vacant lands are very scattered within urban areas (plots with an average area of just 620 m²), and thus they are not really usable for agriculture, except perhaps for urban gardening.

The distribution of the violet class, i.e. parcels located in a rural context, shows that these vacant lands are very isolated and located on steep slopes, thus not really exploitable for agricultural purposes. The blue and the yellow classes have an intermediate situation compared to the previous ones: the parcels present opportunities for agriculture (irrigable, not concerned by clearance authorization). They are located in current agricultural areas or in a suburban context. The orange class, similar to the previous ones, characterizes parcels also suitable for agriculture but in natural vegetation land use and with a forest cover which would require a clearance authorization. The parcels are large and geographically concentrated, in particular in the Gapeau Valley. Possible agricultural development in these areas should consider the conservation of natural vegetation, for instance through agroforestry or natural pastures. The green class also includes lands with forest cover covered by a clearance authorization. Agricultural development should consider non irrigable crops and/ or forestry exploitation.

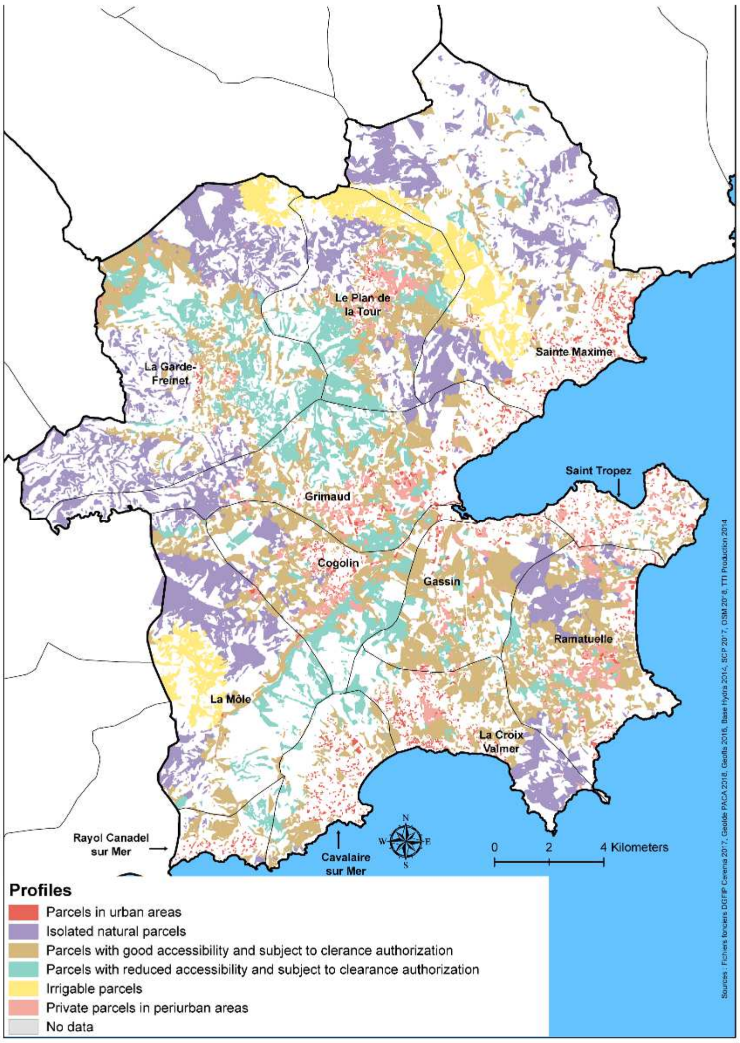

Fig 9: Classes of agricultural opportunities for vacant lands in GST. The colors used in the key are the same as those employed in Table 8.

In Figure 8, the violet and blue classes offer low opportunities for agriculture. Vacant lands are located on the mountains of the Massif des Maures, in a forest-covered area requiring clearance authorization, and where some parcels are very isolated. As in the TPM classification, the red class describes parcels in an urban context with potential for urban gardening. The pink class shows lands where agriculture has to be developed or maintained. Here, the unbuilt or already cultivated lands concerned are close to inhabited areas. However as they are not irrigable, agricultural opportunities are probably limited to viticulture or other rainfed crops, such as agroforestry or permanent grassland. The yellow class includes irrigable parcels and offers a wide range of agricultural possibilities. The brown class offers good opportunities for low water-need agriculture, for example agroforestry compatible with the existing forest cover (e.g. orchards and pastoral farming).

By combining the AHC classification with the scoring analysis it can be seen that for the two case studies, vacant lands with a high score (higher than +1 in Table 6) are mainly concentrated in two classes. In TPM, they are concentrated (97%) in classes 3 and 6. In GST, they are 88% concentrated in classes 4 and 6. In contrast, some classes (like the violet class) do not contain any high-score parcels, confirming that these parcels are not really interesting for agriculture.

TPM			GST		
Class number	ha	%	Class number	ha	%
1	43	2.7	1	1 61	6.2
2	0	0	2	34	1.3
3	1358	85.8	3	133	5.1
4	0	0	4	1552	59.7
5	0	0	5	0	0
6	167	10.6	6	720	27.7
No Data	14	0.9	No Data	0	0.0

Table 8: Distribution of vacant lands with a high score (class > +1) by classes (AHC). The class numbers and colors used in the key are the same as those employed in Figures 7 and 8.

4.4 Scenarios for future agricultural projects

Prospective scenarios can enlighten the public policy debate and more precisely, assess the possible greater place for agriculture. Starting from the hypothesis of agricultural land expansion, we explored a possible pathway for a sustainable planning project. Impacts of an agricultural space increase explored in the normative scenarios were measured through socio-economic indexes.

For the TPM study area, we suggest a scenario focused on market gardening and orchards, given the public’s increasing awareness about short supply chains and organic production. Moreover, a good system of local farmers’ markets is already established in this region. The new agricultural areas should be located in areas where irrigation is available and in parcels not subjected to land clearance authorization requirements. Moreover, a slope criterion is added: irrigated orchards can be located on plots with slopes between 20% and 35%, whereas for plots with an area greater than 3ha and with a slope of less than 20%, specialized market gardening is proposed. Otherwise, a more polyvalent and extensive form of market gardening could be proposed. The map concerning vacant lands suitable for this scenario shows that market gardening would be located in the remaining narrow urban spaces, while orchards are located in valleys with irrigation systems (Figure 10). If this scenario were to be adopted, agricultural areas would increase by 1560 ha, potentially providing 17 million euros of added value in terms of production from the activities, and creating 6,000 jobs.

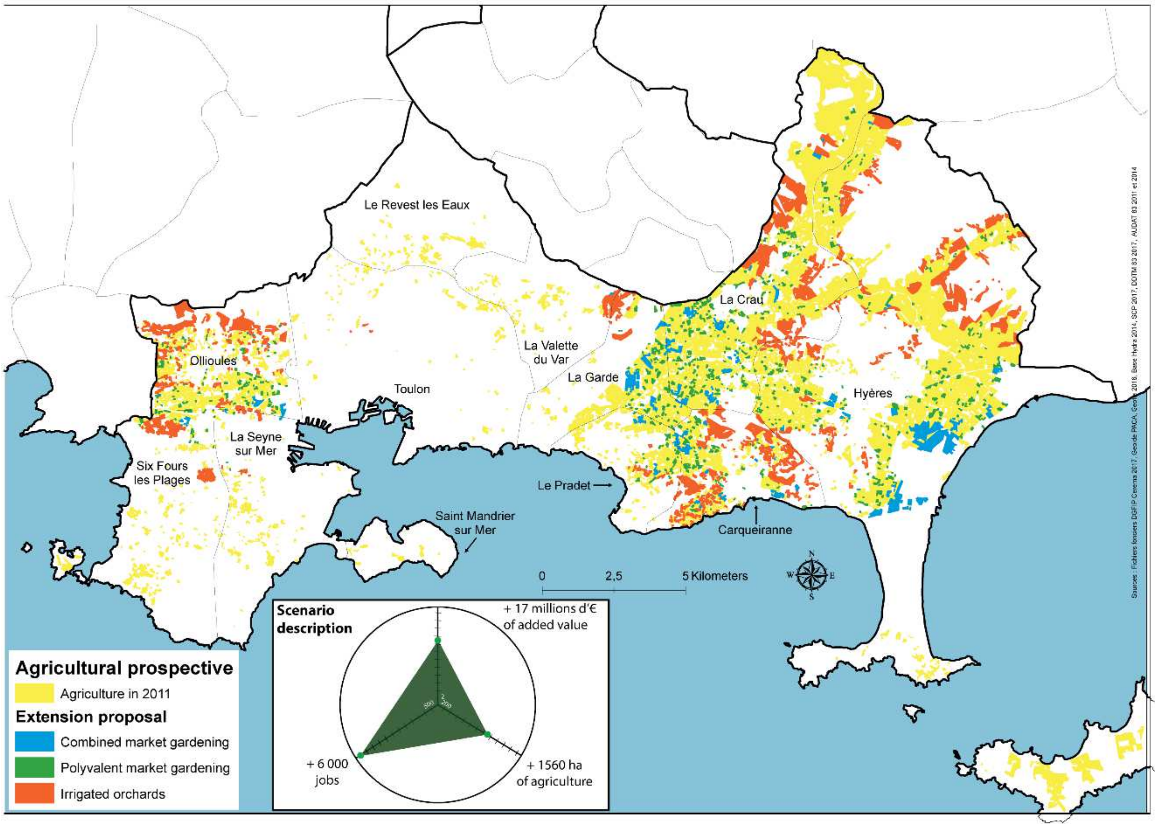

Fig 10: Scenario 2: market gardening and orchards to reach foodstuff self-sufficiency (TPM)

Wine is the leading production for the Var department in terms of surface areas and value. This is why we proposed further developing this agricultural system for the GST study area, possibly associated with other fruit plantations. Such an orientation is also compatible with the context of climate change, as this kind of mixed cropping includes benefits for the thermal regulation of soils, the nutrient supply, etc. Almond production was thus proposed in order to improve crop diversification and because of its low water needs and good potential market valorization (Prgomet et al., 2020; Monks et al., 2017). Moreover, the scenario considered developing new agricultural areas near the already existing ones, on groups of parcels greater than 1 ha (through land consolidation) and not subject to land clearance authorization, therefore not in classified forest areas, in order to preserve the natural vegetation. Results concerning vacant lands suitable for this scenario show a balanced spread of this agricultural development across the territory as well as good conservation of protected forest areas (Figure 11). Under this scenario, the agricultural areas would increase by about 330 ha, with 4 million euros of added value and 620 more jobs created. Fig.11 shows where the new agricultural parcels could be located, and summarizes the economic benefits of the scenario.

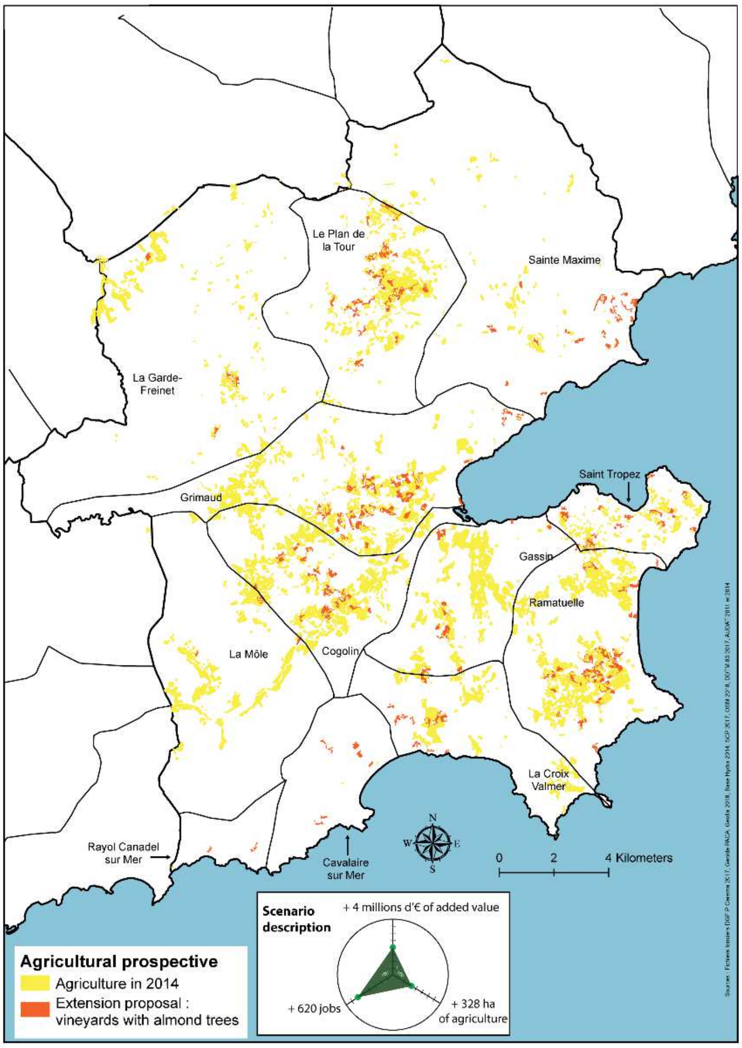

Fig 11: Proposed scenario for the GST study area, with location of vineyards and almond orchards

4. Discussion

4.1 Vacant lands and agricultural valorization

Similar studies on vacant lands have been conducted at a fine scale during the last few decades. Our proposals differ in terms of valorization analysis (e.g. housing development, ecosystem services, urban gardening). The difference concerns also the scale and the extent of the analysis, as well as the associated data and the methodology possible to develop in these contexts. As mentioned in the introduction, different meanings and measurements are used to inventory vacant lands, and thus results are not directly comparable (Newman et al., 2018).

In 2015, Kremer and Hamstead brought out a Special Issue entitled "Transformation of Urban Vacant Lots for the Common Good", in which they estimated the amount of vacant lands in US cities at between 12.5% and 15% of the total land area. These numbers are valid for a restrictive meaning of vacant lands and for a limited urban context. In addition, the results were obtained from remote sensing or photointerpretation methods, which cannot be replicated over a vast area.

Two relevant studies assessed vacant lands for potential greening uses. In the city of São Bernardo do Campo (region of São Paulo, Brazil), Sanches and Mesquita Pellegrino (2016) inventoried 8% of derelict and urban vacant lands (defined as natural abandoned lands > 1ha and determined with a photointerpretation method), and next applied several indexes to estimate their role in the city from different aspects such as ecological or social dimensions. Pursuing the same objective, Smith and al. (2017) applied a more accurate methodology (i.e. using remote sensing and cadastral data) to the Phoenix area. They identified from 4 to 18% of vacant lands mainly located in the core and on the fringe of the different cities, considering vacant lands with different morphological criteria than those used for our analysis (e.g. parcel size from 56 m², <5% slope). Other studies have provided estimations of the amount of vacant lands in a city using sampling and estimation methods, as in Mcdougall and al. (2020) or Kim and al. (2018).

While the majority of vacant lands inventories concern city contexts, in our case studies we enlarged the area of two coastal intermunicipalities, obtaining as a result an amount of vacant lands of 23.5% and 37% respectively for the TPM and GST case studies. Nevertheless, just a small part of this total area of vacant lands has interest for agricultural valorization according to the geographical, physical and regulatory criteria considered in the analysis: in TPM and GST respectively, 61.6% and 33.6 % of the total of vacant lands and almost 14.5% and 12.5% of the TPM and GST intermunicipality area.

Other studies have been carried out with an in-depth analysis of the agricultural potential of vacant lands, for example in the work of Erickson et al. (2013) by the inclusion of data on soil quality. The authors gave an estimation of lands with prime soil in Chittenden County, Vermont, which represent 74% of lands with agricultural opportunity. This finding shows what could be an interesting continuation of our work, with the integration of soil quality data unfortunately not available in our context.

Moreover, our results highlight the proximity of the urban front to the best lands: 60% of spaces newly artificialized between 2006 and 2014 are located within 5 meters of the vacant land parcels with the highest scores. These results confirm previous studies analyzing the artificialization of prime farmlands (Martellozzo et al., 2015; Ceccarelli et al., 2014; Ferrara et al., 2014). In their recent study, Aksoy et al. (2017) showed that France belongs to the group of European countries with the highest quantity of lands where development strongly impacts the biomass productivity potential of arable lands. They also noted that the southern region is considered as a hotspot from this point of view. Furthermore, in a comparison of EU countries, Tóth (2012) demonstrated that the largest total loss of cropland area between 2000 and 2006 (corresponding to half of the total land taken in Europe), occurred in Spain followed by France. Our work can therefore be considered as a confirmation of these assertions.

4.3 Implications for future urban planning and agricultural policies

These findings indicate the need for new protection measures for agricultural lands. More specifically, and beyond the protection of current agricultural lands, what is required is the protection of lands offering opportunities to develop global and coherent agricultural planning projects. In the coastal context, the integrated coastal management tool should better take into account the relationships between settlements and environmentally-important or agricultural areas (Prévost and Robert, 2016; Cori, 1999). This perspective is becoming more and more essential to regulate land use on coastal areas. Past experience has shown that sector-specific regulation (i.e. concerning agricultural lands) is not efficient in the face of market forces. Geniaux et al. (2015) provided an interesting result from their examination of the same cadastral data: in the Provence-Alpes-Côte d'Azur area between 1999 and 2007, land supply (i.e. lands within constructible zoning) reduced significantly (- 40 %, that is -56 123 ha) due to housing increase (+14 %) and changes in urban planning zoning (loss of 55 000 ha). In fact, from local planning documents to national tools of – agricultural – land conservation, current sector-based measures just enable the artificialization process to be slowed down, but do not permit the promotion of agricultural planning projects. A recent measure has been created reflecting this (named the "territorial foodstuff circuit project" based on the agricultural law of 2014), but it has not had much impact up to now (just 150 projects in 2019 whereas 500 were expected by 2020, as indicated by the Caisse des Dépôts). For example, it organizes, at a municipal scale, local channel distribution of the agricultural production to establishments with mass catering. The second pillar of the Common Agricultural Policy (CAP) also represents a tool available for implementing agricultural projects. This co-funding aims to improve the sustainable development of rural regions and communities in the EU (Gomez-Limon and Atance, 2004), and can be integrated in the objectives of local planning (Sanz Sanz et al. 2018). In this sense, the enforced prospective scenarios give a central place to agricultural land valorization and explore a valorization of multifunctional agriculture (e.g. Scorsino & Debolini 2020 ; Renting et al., 2009).

A concerted approach combined with spatial analysis was used for a spatialized and quantitative analysis of the opportunities for agricultural expansion in the territories. In order to encourage public debate on the inventory and prospective scenario results, workshops were organized on the two case studies with local players (Authors, *in publication*). In terms of farming system typology, our choice was to propose scenarios sustainable from both the environmental and the socio-economic points of view. This involved finding a compromise between more agro-ecological systems and specialized/intensive ones. In this paper, we did not analyse the possible use of limited resources in farm management, such as water for irrigation systems, because our scenarios were simply illustrative of the possible realization of break-away futures. Future works in this field should consider these implications (Ricart et al., 2019; Nicholls et al., 2020). Elsewhere, similar normative scenarios have been built with strong hypotheses regarding the need for climate change adaptation (Carter 2018, Milestad et al., 2014; Rounsevell et al. 2006). This parameter is not included in our study, which focused on the present situation to raise questions for decision makers about the existing residential issues of the territory, and the current opportunities to change planning project directions.

4.4 Methodological discussion

In terms of methodology, one of the main challenges was the detailed scale of work. As previously mentioned, all the spatial analyses were carried out at parcel scale in order to enable the use of the results as a base for spatial planning by policy makers. On such a vast study area, the investigations employed mainly land-use data with a larger mesh size (e.g. Corine Land Cover dataset) which just consider polygons bigger than 25 ha (Schmit et al., 2006; Santa Olalla Manas et al., 2003). This potentially hides a part of the vacant lands, in particular within the urban fabric. However, this approach is limited by the low number of relevant datasets available at the parcel scale, and which are therefore not included in the analysis, such as soil quality. Nevertheless, we consider here that the quality of soils is a less determining factor influencing the possibility of extending agricultural development in the case studies than the major factor of land availability. In addition, given the Mediterranean context, several agricultural activities can potentially be developed in most places, like viticulture. A more significant factor is water access, which is included in the analysis.

Another methodological question concerns the choice of thresholds for the scoring settings. Results are sensitive to these settings and may be refined to a more local scale of analysis (e.g. municipal scale).

In scenario building, it should be remembered that the expansion of agricultural lands does not mean that the agricultural activity chain will systematically improve (e.g. in terms of jobs). Socio-economic impacts assessed for the scenarios do show encouraging results (Figures 10 and 11). However, they correspond to global estimations, based on aggregated data. In addition, they are dependent on the current context. Possible macro-economic (e.g. market regulation) or social (e.g. farming conditions) changes may occur in the future, and are not taken into account. In a broader perspective, uncertainty as to the future was not measured here, as the main goal of the normative scenario building was to inform and question local stakeholders regarding the possibility of alternatives to residential development.

Conclusion

In this paper, we inventoried existing vacant lands at the parcel scale in two intermunicipality areas of south-eastern France, characterized by a high urbanization trend and a strong tourism and residential economy. Next, we evaluated the possible opportunities in valorizing vacant lands other than via residential development. Despite the common belief of local stakeholders according to which the MedCoast is now saturated, we found several vacant land hotspots with high opportunities for agricultural valorization in our case study areas. These parcels are especially located on coastal plains, excluding artificialized coastlines and inland mountainous areas. Starting from this inventory of vacant lands suitable for agricultural valorization, two territorial scenarios were built, one for each case study, compatible with sustainable development principles. The two scenarios demonstrated that alternatives to residential development are potentially possible, with the expansion of agricultural activities. At the same time, it can be seen that some vacant lands with higher agricultural interest are threatened by the strong expansion of the urban and periurban front, which is often very close.

A continuation of this study could be to explore a diverse set of other possible future scenarios, which could also consider agricultural systems and food chains in the region which do not exist at present, and taking into account potential future climate change and its impacts on the resource availability. Moreover, our research demonstrated that while vacant lands represent almost half of the intermunicipality areas, those with high interest for agriculture are only 12-15% of such areas. A future line of work should also concern effective agricultural land protection strategies which go beyond the simple issue of urban planning, as the various existing land use regulatory systems have failed to protect such lands (Melot, 2018; Abrantes et al., 2016; Padeiro, 2016; Geniaux et al., 2015).

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