ROUSE

Oliu di Corsica: The challenge of adapting geographical indications to climate change

Fabrice Mattei
Climate Change & IP Group Head

OLIU DI CORSICA: THE CHALLENGE OF ADAPTING GEOGRAPHICAL INDICATIONS TO CLIMATE CHANGE

"Beauty island" and "the mountain in the sea" are the most common terms to designate Corsica. They capture the insular topography characterized by the dual alpine and Mediterranean climates. As one the most wooded Mediterranean island, olive trees (Olea europaea L.) are abundant and imbricated with the island's history, culture and development. The recognition of "Oliu di Corsica" (Corsican olive oil) as an Appellation Of Origin ("AOP") encodes that exclusive terroir-based causal link where the primary input is climate.

Although olive trees grow well under harsh conditions, studies reveal that climate change and its effect on aspects of terroirs such as rainfall, water availability, soil quality, and temperature is already having an effect on some production aspects, quantity and quality, crucial to what brings distinctiveness to Oliu di Corsica ("OdC") These feedbacks raise question as to how conceptions of terroir underpinning the uniqueness of OdC are evolving in the face of climate change.

In this commissioned research, we review the impacts of climate change on the terroir where OdC is produced and explore adaptation strategies to climate change to provide an incentive for producers to adapt their production and post-harvest systems to evolving agronomic conditions at the horizon of 2050. These adaptations raise critical issues including as to how the rules underpinning the distinctiveness of the AOP could evolve in the face of climate changes especially in relation to expanding the plantations under non raid-fed conditions (Marescotti et al. 2020).

1. Syndicate of the AOP "Oliu di Corsica"

The syndicate is the defense and management body that represents all producers of the AOP "Oliu di Corsica" ("OdC"). Since its establishment in 2004, its main missions are to guarantee the typicality of the OdC, monitor the compliance of producers with the OdC's requirements and take actions against frauds. The total number of producers are 179 divided into two groups, professionals for one half, semi-professionals and hobbyist for the second half. The 646 cultivated hectares consist of 128,000 olive trees, the average annual production of olive oil is 143,000 liters (SIDOC 2017), (European Market):

	2014	2015	2016	2017	2018
Number of producers	188	195	176	176	179
Production area (hectare)	646	656	612	612	646
Quantity (liters)	178.000	73,000	173,000	104,000	193,000

The production of OdC represents only 3.5% of France olive production while in 1940 the commune of Balagne was producing more olives than the whole country. 69 % OdC is sold in Corsica, 30 % in mainland and 1 % is exported. The average price of 1 liter of OdC sold in Corsica is 20 Euros. OdC oil sold in Corsica is about 25 % cheaper than in mainland and foreign marketplaces.

The estimated market share of OdC varies annually based on the production and alternative year of production.

OdC sold at supermarkets:

Years	Glass bottle			Metal	
	0.75L	0.5L	0.25L	0.7L	0.5L
2012	18.80	20.09	22.80	20.19	22.48
2017	21.47	23.16	28.96	21.37	25.50
Price increase	12 %	13 %	21 %	5.7 %	12 %

Average price increase of OdC from 2012 to 2017 is **12.74%.**

Odc sold at boutique/stores:

Years	Glass bottle			Metal	
	0.75L	0.5L	0.25L	0.7L	0.5L
2012	24.16	28.62	38.48	25.24	29.78
2017	30.50	35.00	40.20	31.70	39.40
Price increase	21 %	16 %	4 %	20 %	24 %

The average price increase of OdC from 2012 to 2017 is 17 %. In comparison, the price increase of none AOP olive oils for the same period is only 6 %. Despite its small production, the OdC is recognized and accepted by customers and enjoys a constant price increase which is higher than other olive oils.

2. Climate

The climate is dominantly Mediterranean, with alpine influence that generates heavy precipitations including snow (Ponti et al. 2014) More specifically, Pierre SIMI and Jacques GAMISANS have identified three distinct climate influences based on the topography (Fig,1).

- Mild and humid Mediterranean climate, at the altitude between 0 and 600m, characterized by average annual temperatures ranging from 14 to 17 °C, with good but irregular amounts of precipitation and a period of significant summer drought;
- Mediterranean climate of altitude, at the altitude between 600 and 1,200m, characterized by average annual temperatures ranging from 10 to 13°C with average annual precipitation ranging from 800 to 1,500 mm and a still-severe dry spell;
- High-altitude Mediterranean climate, at the altitude above 1,200m, cold and humid, with abundant snow cover and very short periods of drought.

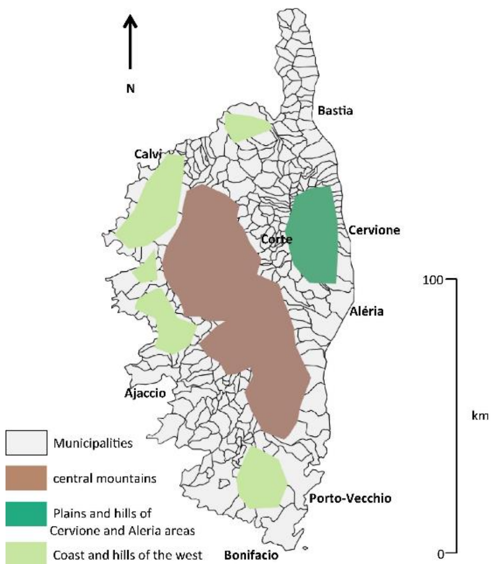


Figure 1: Map of Corsica highlighting mountain, plains and coastal areas, all being subject to different types of climates

Winds have significant impacts on the climate of Corsica. (Fig.2) They can be classified by their frequency and intensity: - Tramuntagna (Tramontane), northerly wind, cold, - Mistrali (Mistral), northwest wind, dry in summer, wet in winter, - Libecciu (Libeccio), south-westerly wind, dry in summer, very humid in winter, - Siroccu (Sirocco), south to southeast wind, warm load of Sahara sand , - Grecale (Grégal), north-easterly wind, wet in spring and autumn, - Levante (Levant), eastbound, - Punente (Ponant), westerly wind (Gobert et al 2019) (Fullgrabe et al. 2020).

Figure 2: Types and direction of winds

The evolution of temperatures from 1950 to 2018 in north (Bastia) and south (Ajaccio) increased by 0.9°C in the last 45 years (Synthese 2017), approximately 0,2°C per decade (Fig.3 a). There is also a noticeable increase of anomalies (Fig. 3 b).

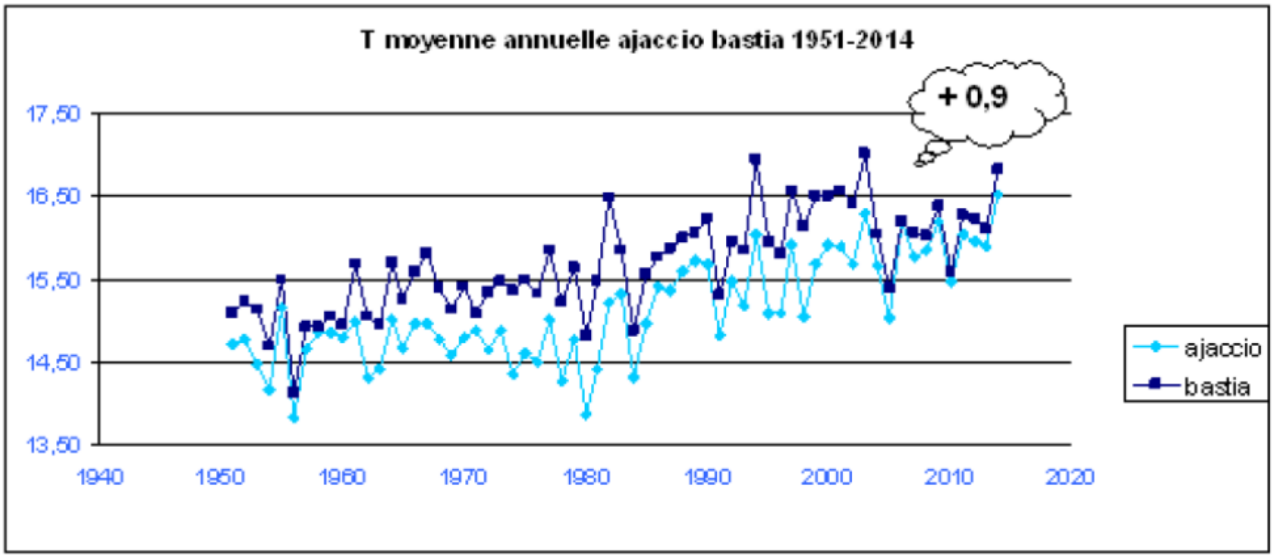


Figure 3 a: Temperature trends in °C from 1970 to 2015 in Bastia and Ajaccio

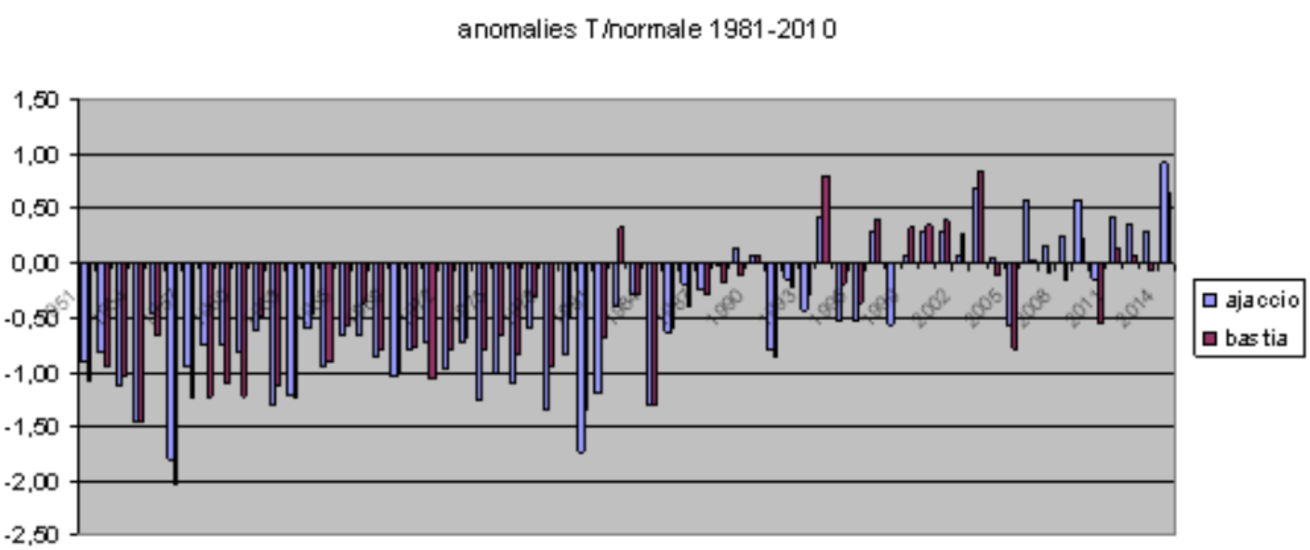


Figure 3 b: Anomalies in temperature in Ajaccio and Bastia in °C between 1981-2010.

The temperatures vary from approximately 10°C during winter to 28°C in the summer (Fig.4).

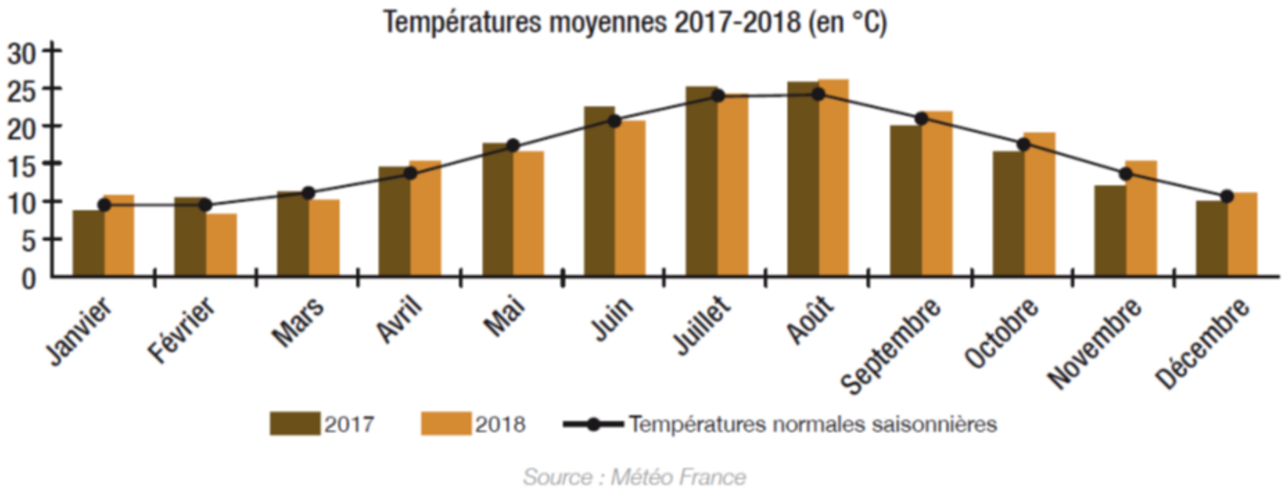


Figure 4: Average monthly temperature in °C Corsica between 2017 & 2018

The evapotranspiration follows a similar trend as the temperature with a constant increase between 1970 to 2016 and have observed that the evapotranspiration overtakes the precipitations which then enhance the risk of drought (Fig.5).

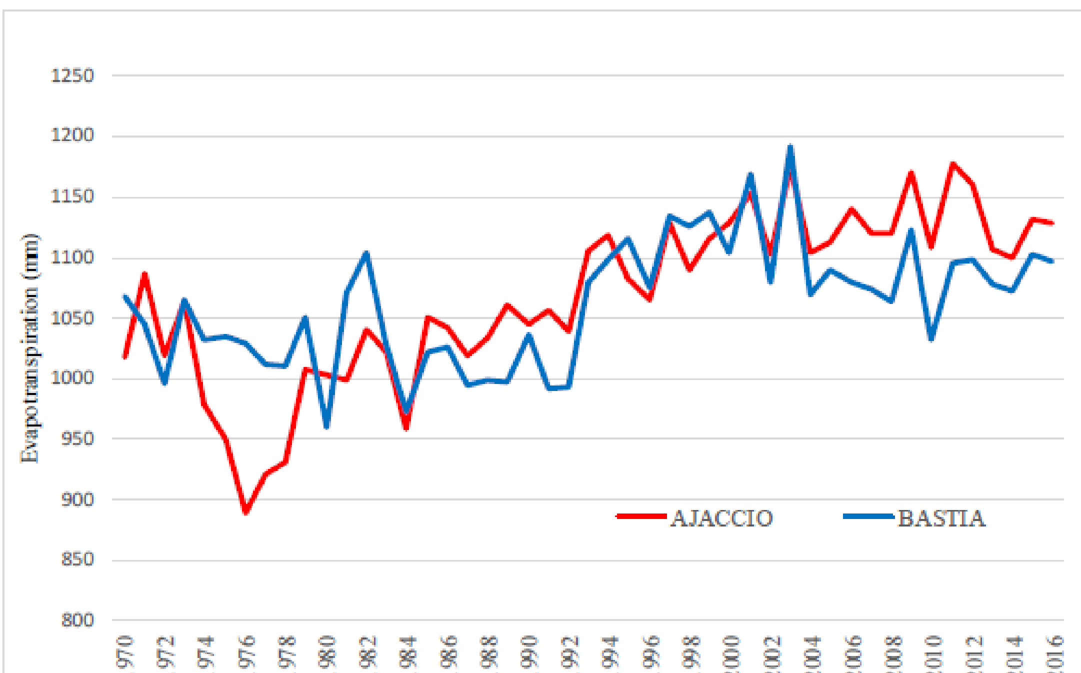


Figure 11 : évapotranspiration (en mm) à Ajaccio et Bastia depuis 1970 (Mori et al., 2017)

Figure 5: Evapotranspiration trends from 1970 to 2016 in Ajaccio and Bastia

According to Météo France there is a great variation in precipitation from one year to the next. However, a trend of a slight decrease in annual precipitation can be observed over the period 1959- 2009. illustrates this variability and the difficulty of identifying a significant trend. They describe the decade 1981-1990 as "very dry." The decade 1991-2000 is characterized by a series of significant surpluses and deficits. The decade 2001-2010 is characterized by a dry period followed by wetter period.

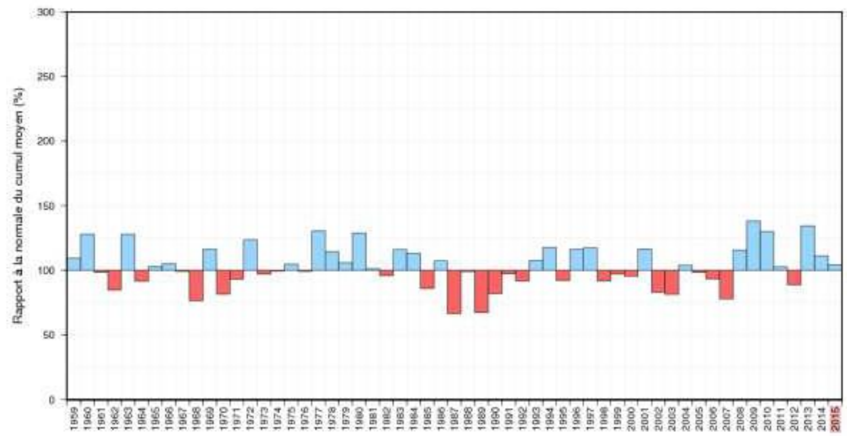


Figure 6: Average precipitations in Corsica from 1959 to 201 (with respect to the average in %)

More precise information on the number of days of water stress have been collected in specific areas where major olive orchards are located. The data indicates an overall increase of water stress. The hottest years in the last 15 years were 2003, 2006, 2014, 2015 & 2017 (Figs.7, 8 & 9) (Expert Mission 2019).

Patrimonio

Figure 7: Number of days of water strees

Ville di Parasio

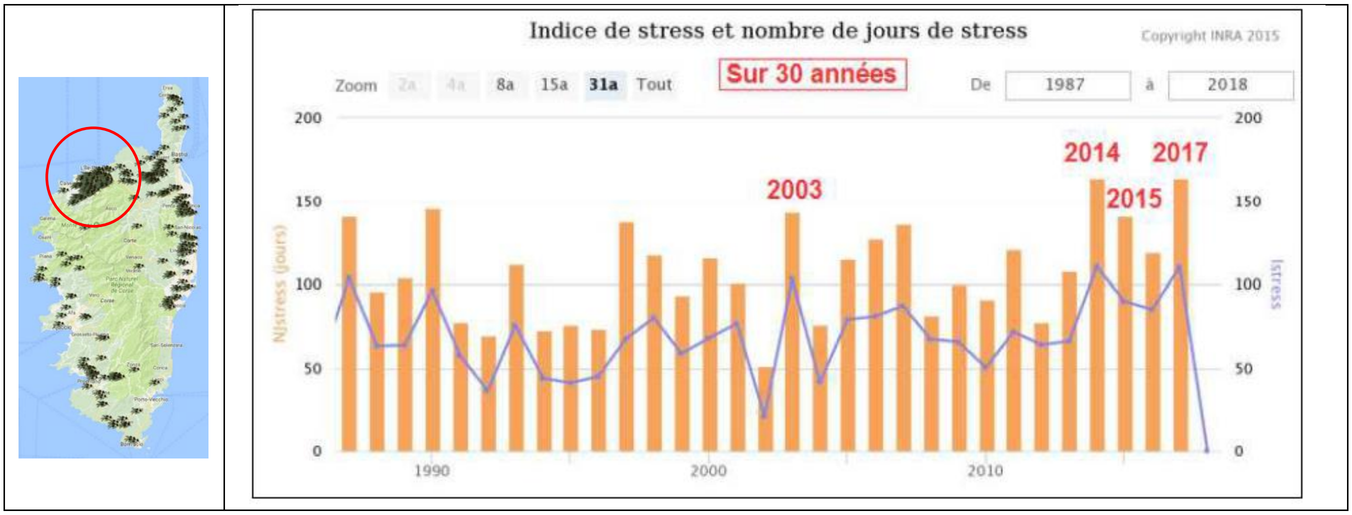


Figure 8: Number of days of water strees

Ghisonaccia

Figure 9: Number of days of water strees

The number of warm days (>25°C) has increased by 5-6 days per decade while the number of frost days has decreased by approximately one day per decade (Synthese 2017).

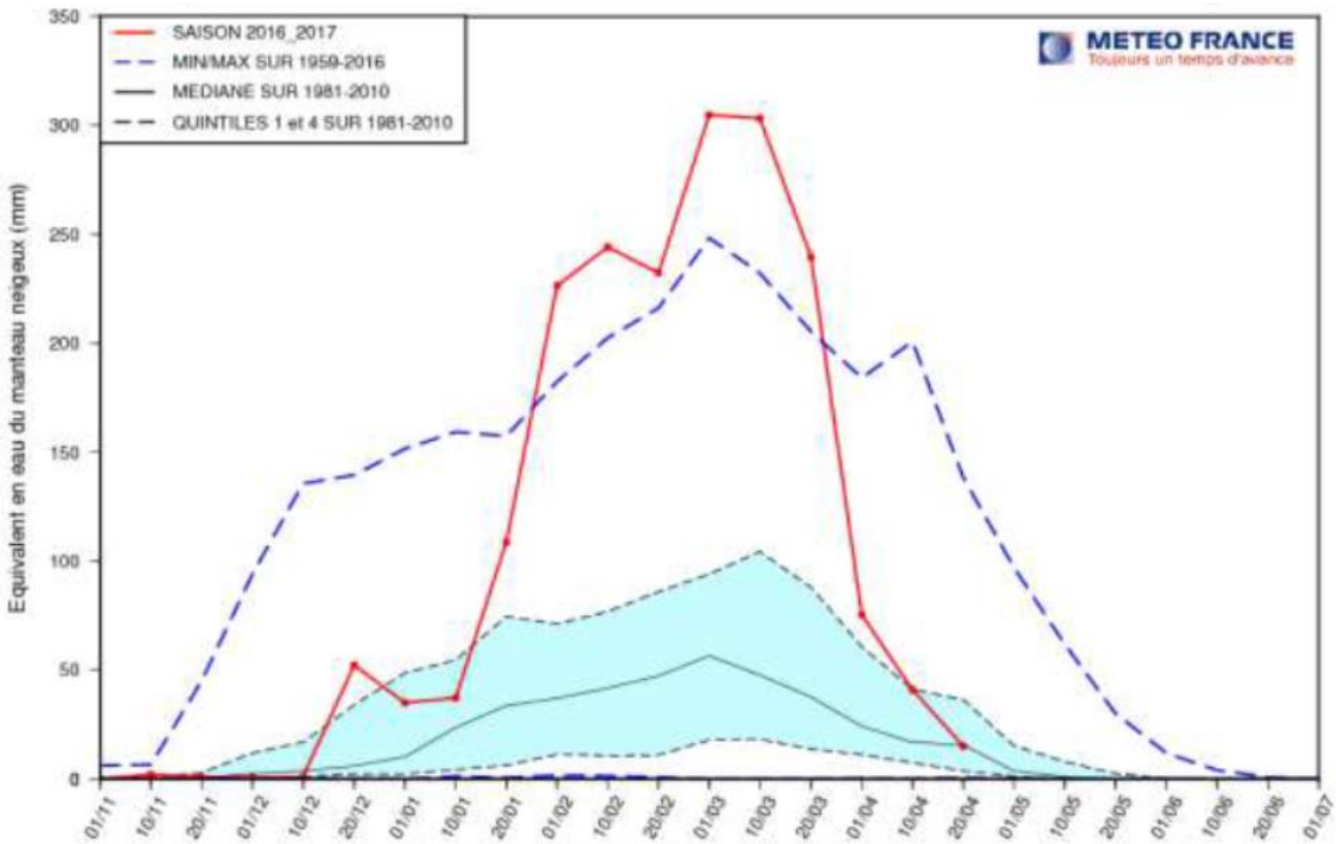


Figure 10: Equivalent in water of the snow cover (Red color: 2016-2017, Doted blue color: Minimum and maximum between 1959- 2016, Black color: average 1981-2010)

3. Projected Climate Change at the horizon of 2050

The projections are based on (i) the Representative Concentration Pathways (RCPs) adopted by the IPCC in its Fifth Assessment Report, namely RCP4.5 and RCP8.5 (ii) RCMs data from EURO-CORDEX and DRIAS (iii) Report CARD and (iv) the Agro Ecological Zoning(AEZ) method to assess impact on olives.

From a big picture, the climate of Corsica will remain Mediterranean and won’t convert into arid even in RCP 8.5 scenario. However, a small decrease of precipitation could result in a transition from Mediterranean to arid climate type (Barredo et al. 2018)

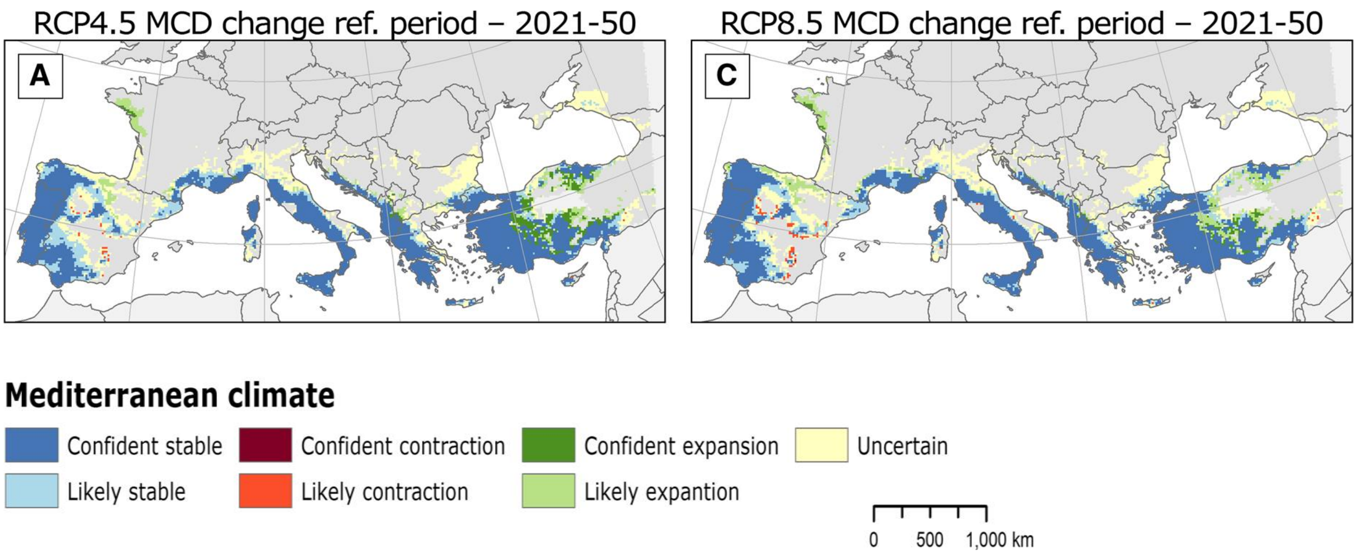


Figure 11: Projected changes of the Mediterranean climate domain (MCD) under scenario RCP4.5 and RCP8.5 in two future periods in relation to the reference period (1981–2010). a, b Changes under scenario RCP4.5 in the 2021–50 and 2071–00, respectively; c, d Changes under scenario RCP8.5 in the 2021–50 and 2071–00, respectively. White: outside the spatial domain of the RCM simulations

Temperature	Precipitation	Snow	Winds	Heat & cold waves
According to the IPCC 2016, a substantial rise in temperatures of around 2 °C depending on seasons and scenarios from now until 2050. the rise in temperatures in the Mediterranean will be higher than the rise of temperatures worldwide and the rise in temperature in mountainous regions of Corsica is expected to be more substantial. Under the scenario RCP 4.5 the temperature increase 1 to 1.5 °C and 1.5 to 2 °C during summer time.	The 5th Report of IPCC indicated that the annual number of rainy days is very likely to decrease while the risk of summer drought is likely to increase in the Mediterranean area.	The SCAMPEI project concluded that a decrease in the number of number of days of snow per year (up to 5 cm) including at 1500m altitude with -60% by 2050. At high altitudes (2400 m) the expected decrease is -30% by 2050.	Analysis of the wind regime is ongoing, preliminary in Calvi. First results indicate that there are anomalies with a decline of winter wind intensity, particularly in the Northeast sector.	According to Aladin and WRF modeling provided by DRIAS there is no projected heat waves but an increase of warm days (average temperature >25°).
Sources: IPCC, Report CARD, Agro Ecological Zoning(AEZ) method. ENSEM-BLES project (EC-FP6-ENV). model (NCAR-CSM, EURO-CORDEX horizontal resolution of * 12.5 km	Sources: IPCC, Report CARD, Agro Ecological Zoning(AEZ) method, ENSEM-BLES project (EC-FP6-ENV). model (NCAR-CSM), EURO-CORDEX horizontal resolution of * 12.5 km	Source: SCAMPEI (http://www.umr-cnrm.fr/scampei/)	Source: STARE-CAPMED Goffart et al., 2015; Fontaine et al., 2016	Source: Aladin WRF modeling Med-CORDEX
Figures 12 a) b) c)	Figures 13 a) b) c)			

Temperature

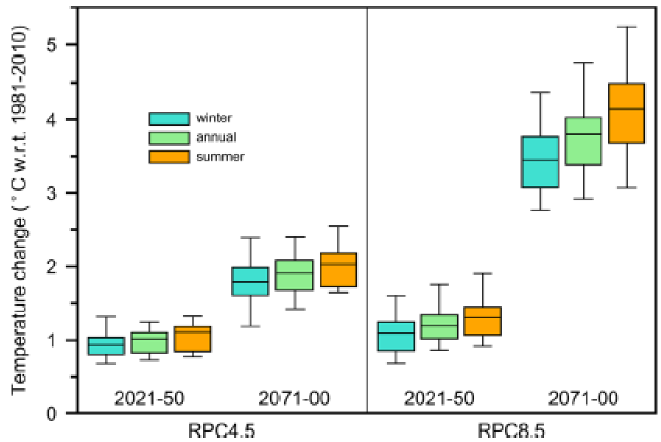


Fig 12: a) projects increase of temperature between 0.7°C o 2 °C

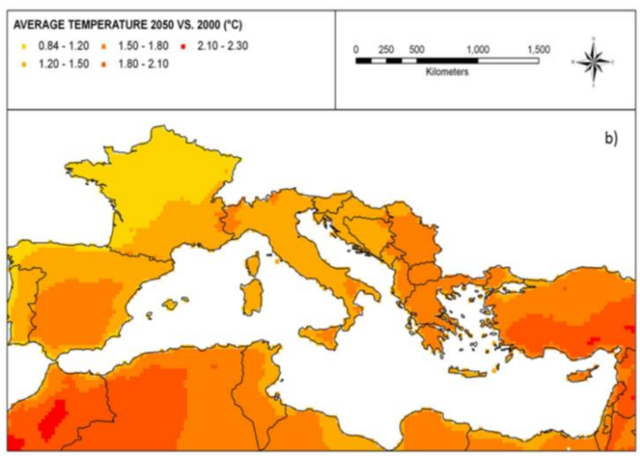


Fig. 12: b) projects increase of temperature between 1.2°C to 1.5 °C depending of RPC by 2050

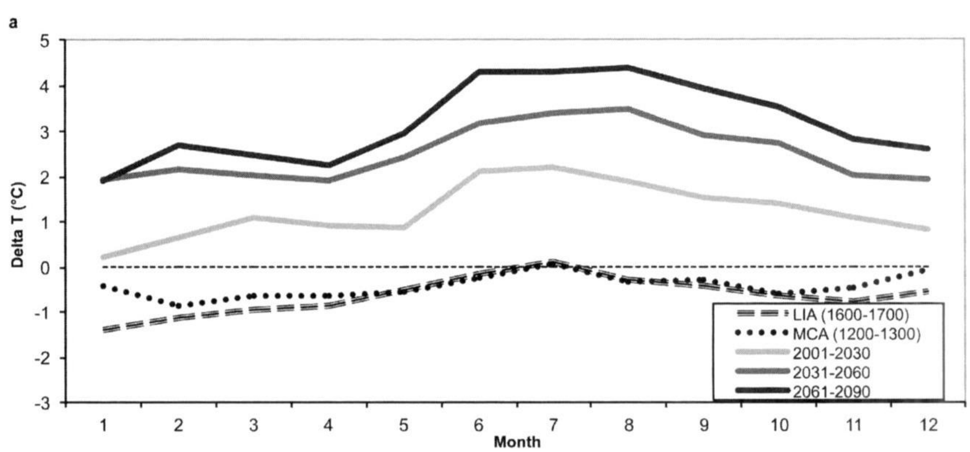


Fig 12: c) projects an increase of temperature between 2031-2060 of an average of 2.2 °C.

Precipitation

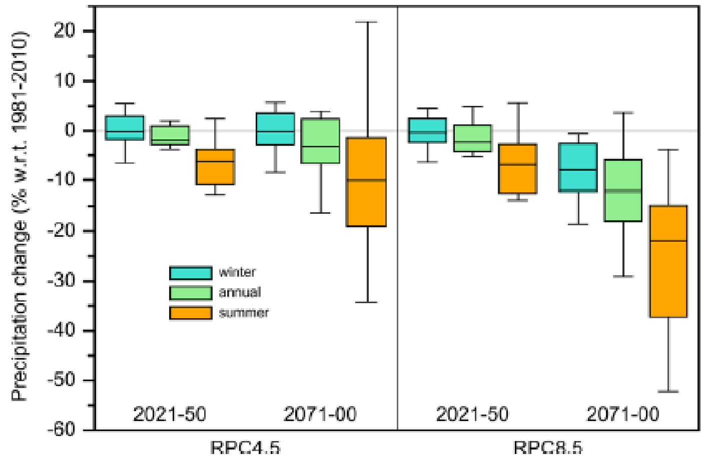


Fig 13: a) projects a decrease of precipitation in summer between 5 to 15 %.

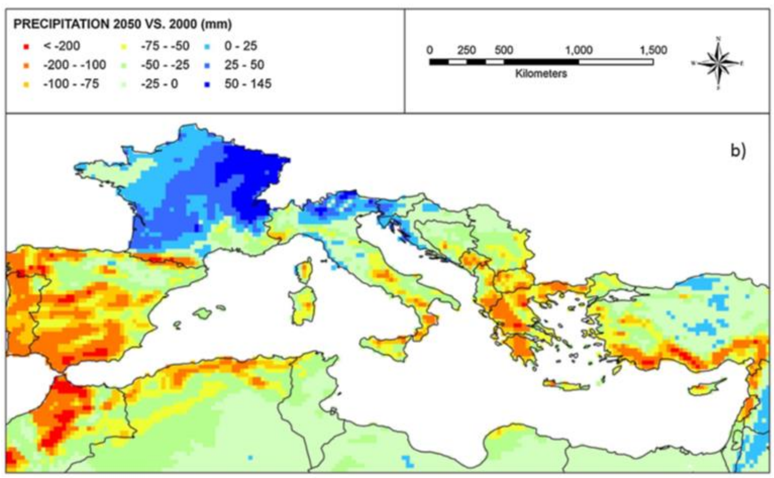


Fig 13 b) projects a decrease of precipitation in summer between 200-100 mm.

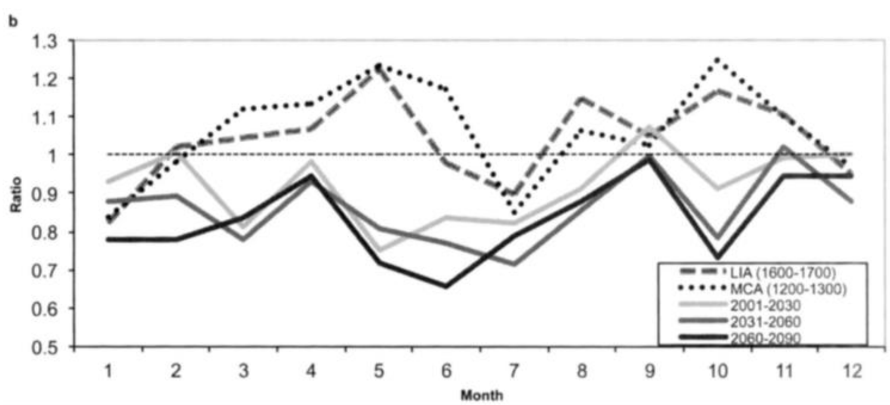


Fig 13 c) projects a decrease of precipitation between 2031-2060 of an average ration of 0.8.

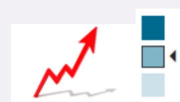
Vulnerabilities

Ratings: high for elements which are certain medium for elements for which doubts exist, low for elements which remain within the realm of hypothesis.

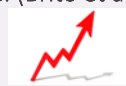
: deteriorate

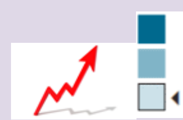
: improve

Types of vulnerability	Past	Present	Future
People	Most olive plantations grow on the slopes of hills. Pruning and harvesting are done manually due to the topography. Growers are exposed to various risks ranging from heatwave to flooding (Michalopoulos et al 2020)	temperature and warm days increase in magnitude and intensity.	temperature and extreme events increase in magnitude and intensity. Precipitations to decrease further impacting working conditions of olive growers.
	wildfires exacerbated by the lack of forests management expose growers to high risks (Vaiciulyte et al. 2019)	Better forest management helps reducing the intensity of wildfires.	higher fire occurrence is expected in shrublands due to further land abandonment & temperature increases[1]
	Reduction of olive production started in 1940 due to market competitiveness and land abandonment impacted growers' revenue (Mouillot et al. 2005)	Olive oil production is now stabilized mainly due to the AOP system providing income to growers	Projected decrease of production due to climate change. Rigidity of AOP system blocking major adaptations to the production process.
		Properties price increase in villages surrounding olive orchards caused by tourism are unaffordable to growers.	Projected tourism slowdown due to hot summers. Properies price may then reduce. Iincreased urbanization target valley and areas

People			close to the sea reducing opportunities to growers for planting their trees in more friendly environment that hills 
		Olive growers' lower income caused by a decrease of oil production volume caused by climatic reasons force olive growers to have multi jobs to meet financial needs (Montanaro et al. 2018)	The climate change and slowdown in tourism are expected to impact the production and sales volume of olive oil. 
		The AOP's rules on varieties, cultivation and irrigation are not compatible with the effects of climate change. 65 % of all olive oils produced in Corsica are AOP (Belletti et al 2015).	Unless amended, the AOP rules won't allow growers to cope with climate change effects. 
			Due to expected lower production and lower sales volume the number of mills will reduce exacerbating production costs. 
			The attractivity of the island and life quality will be impacted 
			Risk of scarcity of olive oil produced and available on the island. 

Markets	The production volume and price of olive oil have declined from 1940 to 2004 where the AOP was established.	Due to climate change the optimum production of the AOP (estimated at 500) can't be achieved. The AOP is mainly sold in Corsica at a lower price than if it will be sold at overseas markets.	Expected lower production and lower sales volume due to worsening of climate conditions and tourism slowdown. New producing areas in Europe competing against Corsica.
		Lowered acetic acid which negatively impact the olive flavor.	Expected further decrease of acidity due to the increase of temperatures. Customers may stop busying because of overly sweet aroma.
			AOP may be abandoned by olive growers who can't cope with climate change.
Production process and delivery	Trees are damaged due to extreme events impacting oil production.	There is an increase in extreme events. 38 were recorded from 1958 to 2017, versus 4 in the previous 120 years	Projected temperature increase is likely to result in an increase of extreme events.
	Due to temperature increase, the 'Olive fly" started infesting olive trees, impacting oil production.	Current high risk of pest infections including "Xylella Fastidiosa" (Bosso et al. 2016)	Olive fly may disappear from Corsica due to higher temperature, however it may be replaced by new ones requiring medium/high, use of insecticides.
	Waste away of olive trees due to serious droughts that started in 2017.	Continuous waste away due to the increase of drought.	High risk of increase of waste away due to the increase of drought.

Production process and delivery		Climate sensitiveness in the production, transportation and storage cycles.	Climate sensitiveness in the production, transportation and storage cycles making OdC improper to sell. 
	Among olive varieties, there are significant differences in responses to climate-related stresses.	Under the AOP system, only Corsican varieties are used (Bronzini et al. 2002)	Varieties unsuitable to temperature increase which will require changing AOP rules and new orchards which will take at least 5-7 years to produce oil. 
	Periodical events of water stress.	higher water demands and lower water availability, will enhance water stress for olive trees in the future. (Brito et al. 2019) 	Increasing water demand since irrigation augments productivity (Alfieri et al. 2019) 
	Yields decrease due to land abandonment, rural exode, price decreases.	Yields are stabilized due the AOP system (Fraga et al. 2019). 	climate change may negatively impact the viability of olive orchards and yields. 
Premises	Land abandonment especially between 1940-2000 resulting in wasting away of trees, infestation, lower yields and wildfire increase See Appendix 1	Improved management of wildfires (Garbolino et al. 2016) (Ager et al. 2019) 	Increased risk of wildfires and for plantations near the littoral, increased risk of flooding and sea level increase 
		Plantation of these trees under exclusively rain-fed conditions and urbanization refrain plantations into valleys	Plantation of olive trees under exclusively rain-fed conditions will probably be impossible. 
		Evapotranspiration increase, contributing to soil warming	increased drought could increase fire activity on most Mediterranean

			islands, with secondary effects of land degradation and soil erosion. 
		Drought issues	medium/high fertiliser input, use of herbicides and insecticides. 
Premises	Corsica is one of the alien plants most invaded Mediterranean. (Médail et al. 2017).	increase of alien plants' invasion due to tourism and need for drought resistant plants.	Expected increase of invasion due to tourism and need for drought resistant plant varieties 
	Olive groves provide habitats and food for several species of insects and larger animals.	Decrease of biodiversity due to waste away of trees	Decrease of biodiversity due to waste away of trees and urbanization. 
			shift in new areas suitable for olive growth outside of Corsica due to further increases in temperature and reductions in rainfall, as projected (Clark et al. 2017) 
Finance	Irrigation systems on hilly areas is costly to install and maintain (Fraga et al. 2020)		Risk of olive oil not to meet AOP requirements are high, growers can't sell their olive at profitable price. 

Finance			Olive is vulnerable to climate variability and change since it is cultivated mainly in rainfed. The time required for replacement of varieties by new drought resistant ones requires high economic investments. 
	Pesticide control adds on production costs	Pesticide control (olive fly) adds on production costs 	medium/high fertiliser input, use of herbicides and insecticides.  
		Wildfires and extreme events insurance coverage (Varela et al. 2019)	Insurance issues: increases of cost due to wildfire projected risks  
		Moving from high to low altitudes to achieve better yields and improve efficiency require high investments due to high land price. 	Purchase of lands at low altitude to cope with climate change will incur further high costs  

Adaptation strategies

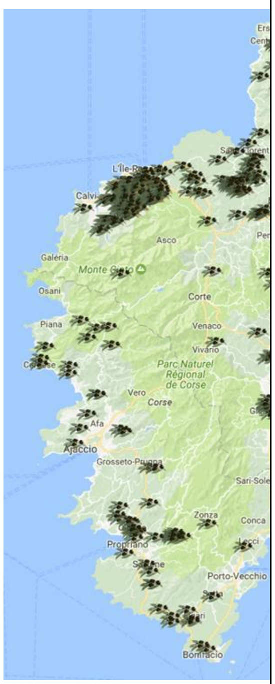
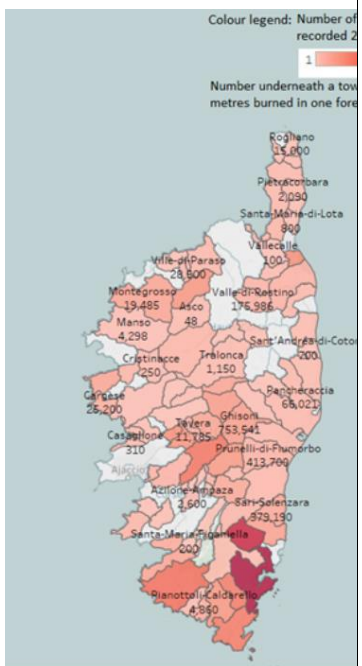
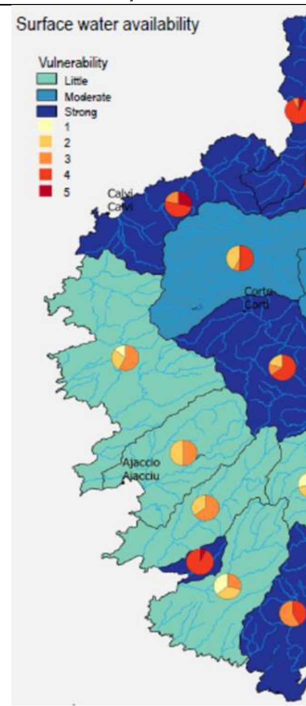
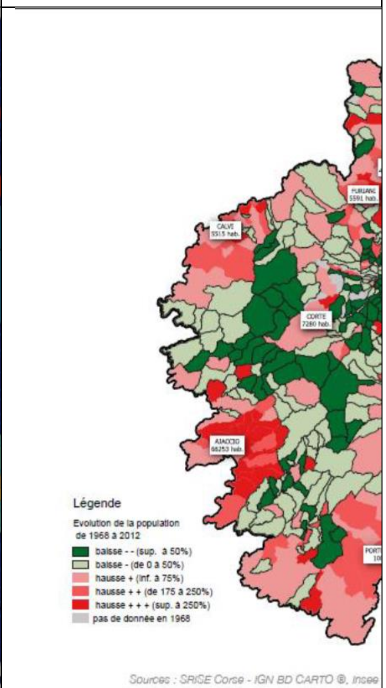
	Adaptation measures	Obstacles
People	Discourage growers from growing olive trees at high altitudes and warn them that doing so will be risky since the annual rainfall amount is expected to fall considerably.	Local & cultural resilience. High prices of land in valley area.
	Discourage growers to engage in monoculture (olive production only)	Lack of skills and infrastructure to grow other crops.
	Prioritizing low-medium altitude growing areas since water-harvesting techniques in high altitude are difficult to arrange (mobilization of important quantities of runoff to supply the trees with water).	Land prices & availability of lands at low altitude.
	Improving wildfire prevention and forest management.	Costs on landowners to better manage their lands and municipalities
	Orientation towards quality and differentiation olive oil rather than volume and add flexibility to the AOP system by allowing amendments for olive growers to better cope with climate change.	Rigidity of the AOP system.
	Synergies between mills and tourism, cultural and recreational activities to maintain local activities, sales volume and employment	Potential impact on the biodiversity due to tourism activities near olive orchards.
	Increase the role of cooperatives, for milling and trade. Incorporation of bottling facilities, allowing direct marketing from producers.	Capital investment, interprofessional cooperation.
Markets	Subsidiarized aids to small-medium size plantations on the basis that olive oil production has, overall, a positive carbon absorption effect facing worst alternatives such as land abandonment and desertification and that reforestation is complex.	Financial obligations at the local and EU levels.
	Develop market opportunities outside of Corsica and France to allow higher revenue & stronger sustainability to growers	Implementing a distribution channel in key market areas (US, Japan etc) and too low and irregular production volume of OdC to meet international market demand.
	Develop branding strategies, promotion of campaigns & contests prizing emphasizing quality/taste and regional origin. Openly raise climate change issues and how the AOP adapts to it without transgressing the quality and origin. Traditional deficiencies in marketing to be corrected through investment in improving bottling and packaging.	Investment from local brand owners & the Syndicate

	Develop organic cultivation methods to avoid/reduce further reduction of the oleic acid due to climate change.	Organic method may be insufficient and too costly. It is not recommended to artificially adjust pH unless there is an absolute need to do so as in wine making (e.g. adding tartaric acid) and the AOP rules will need to be changed.
Production	Cessation of olive desuckering waste burning use as soil cover. The use of cover crops managed through mowing reduce soil erosion, reduction of run-off, (enhancement of water retention preventing soil erosion). Small-scale composting of organic raw materials derived from olive oil mills. No tillage to reduce economic and environmental costs related to fuel consumption required for traditional practice; promotion of cover crops Development. Promoting pruning techniques to enhance within-canopy light distribution (photosynthesis oriented) and aeration of the foliage and good development of bearing shoots.	Cost and time in training on conservative agricultural practices, Reduced yields and/or increases in costs may reduce the viability of using traditional methods.
	Consider testing and using drought/heat resistant olive varieties. Developing endemic olive seeds bank	Resistance from local olive growers based on contamination risks and need to amend the AOP rules.
	High altitude land use areas conversion into forest	Financial incentive system
	Irrigation system Expansion of the use of decanters to reduce water Wastes. Sectors in north, center and south of Corsica highly vulnerable to climate change for surface water availability, Priority sectors where adaptation measures should be established.	Financial incentive system
	Addressing Olive fly through organic and traditional method (patch system)	Skepticism from growers as to the efficiency of the patch system vs. insecticides. Labor intensive process. Potential impacts on bees.

Premises	Subsidies to address land abandonment.	Investment
	Modify cultivation and irrigation AOP rules.	Amend AOP rules is arduous and time taking.
	Prioritizing low-medium altitude growing areas since water-harvesting techniques in high altitude are difficult to arrange (mobilization of important quantities of runoff to supply the trees with water).	Land prices & availability of lands at low altitude.
	Stronger controls to imported plant species to reduce contamination and infestation risks	Logistic and cost
	Promote the use of olive tree is a natural barrier against fire. European funds have been dedicated to forest protection in the fight against fire.	Financial support.
Finance	Reserving agriculture lands in Corsica to local Corsican only	Amending the French Constitution
	Implementing irrigation system in priority zones	Financial obligations on the collectivity, water resources management
	Syndicate understating a wider ranger activities in light of CC threats	Membership fees to the Syndicate to substantially increase
	cultivation could be eligible for future investments related to the carbon credit market (Proietti et al. 2017)	Acceptance of olive trees in Emission Trading system.

ANNEX 1

Comparative maps of Corsica based on plantation areas, forest fires risk, surface water availability and population growth.

<table>
<tr><th>Olive tree plantation areas</th><th>Number and intensity of forest fires</th><th>Surface water availability</th><th>Population growth</th></tr>
<tr><td>
</td>
<td>
</td>
<td>
</td>
<td>
</td></tr>
</table>

ANNEX 2

Amendments to AOP for olive oils in the EU based on climate change impacts.

We have analyzed amendments to the product specifications of registered geographical indications for olives. According to the EU Database of Origin and Registration (eAmbrosia), there is a growing number of amendments caused by climate change ranging from changes of oleic acidity to altering the geographic scope of the defined area of a geographical indication, summarized in the below table.

Geographical indications	countries	Type of amendment	Years	causes
Olives Noires De Nyons	France	Change of production area	2007	withdraw 6 communes from the geographical area defined for the designation. The reason for this proposal is that the land in these communes is not regularly used for agricultural purposes and geological, pedological and climatic factors make it unsuitable for cultivation of the type of olive concerned.
Huile D'olive De Nyons	France	Change of GI area (removal of communes)	2007	The reason for this proposal is that the land in these communes is not regularly used for agricultural purposes and geological, pedological and climatic factors make it unsuitable for cultivation of the type of olive concerned.
Chianti Classico	Italy	Change of organoleptic table	2010	So far as regards the oleic acid value, the bad weather in some seasons has delayed the ripening of the olives with regard to the main biochemical aspects, resulting in lower values in that respect.
Brisighella	Italy	Change of harvesting date	2015	This amendment became necessary because of the unusual climatic conditions observed during the year, which caused the olives to ripen early
Vulture	Italy	New olive tree varieties Lower oleic acidity from ≤ 0,5 % to ≤ 0,38 %.	2016	Not indicated but presumed to be due to climate change.
Aprutino Pescarese	Italy	Change of harvesting date	2016	This amendment became necessary because of the unusual climatic conditions observed during the year, which caused the olives to ripen early
Terre Tarentine	Italy	Change of product description	2016	The difficulties were put down to momentary and short-lived adverse local circumstances.

				Only subsequently was it realized that it was not a case of temporarily adverse local circumstances but in fact the result of widespread conditions that were most probably produced by climatic and environmental changes.
Veneto Valpolicella, Veneto Euganei E Berici, Veneto Del Grappa	Italy	Increase of production from 7000 kilograms to 9000 kilograms per hectare	2018	This amendment became necessary because of the unusual climatic conditions observed during the year, which caused an increase of production.
Garda	Italy	From 6,000 to 7500 kgs per hecatre	2018	This amendment became necessary because of the unusual climatic conditions observed during the year, which caused an increase of production.
Colline Di Romagna	Italy	Change of harvesting date	2019	This amendment became necessary because of the unusual climatic conditions observed during the year, which caused the olives to ripen early
Molise	Italy	Change of acetic	2019	Climate change
Colline Teatine	Italy	Change of harvesting date	2019	This amendment became necessary because of the unusual climatic conditions observed during the year, which caused the olives to ripen early

BIBLIOGRAPHY

Ager, A. A., H. K. Preisler, B. Arca, D. Spano and M. Salis. (2014), 'Wildfire Risk Estimation in the Mediterranean Area: Mediterranean Wildfire Risk Estimation', Environmetrics (London, Ont.) Vol. 25, No. 6, pp. 384-396.

Alfieri, S. M., M. Riccardi, M. Menenti, A. Basile, A. Bonfante and F. De Lorenzi. (2019), 'Adaptability of Global Olive Cultivars to Water Availability under Future Mediterranean Climate', Mitigation and adaptation strategies for global change Vol. 24, No. 3, pp. 435-466.

———. (2019), 'Adaptability of Global Olive Cultivars to Water Availability under Future Mediterranean Climate', Mitigation and adaptation strategies for global change Vol. 24, No. 3, pp. 435-466.\

barredo, giovanni caudullo, achille mauri, 2017, mediterranean habitat loss under rcp4.5 and rcp8.5 climate change projections — assessing impacts on the natura 2000 protected area network, eur 28547 en, doi:10.2760/622174

Barredo, J. I., A. Mauri, G. Caudullo and A. Dosio. (2018), 'Assessing Shifts of Mediterranean and Arid Climates under Rcp4.5 and Rcp8.5 Climate Projections in Europe', Pure and applied geophysics Vol. 175, No. 11, pp. 3955-3971.

Belletti, G., A. Marescotti, J. Sanz-Cañada and H. Vakoufaris. (2015), 'Linking Protection of Geographical Indications to the Environment: Evidence from the European Union Olive-Oil Sector', Land use policy Vol. 48, pp. 94-106.

BOS of Oliu di Corsica available at XXXX

Bosso, L., M. Di Febbraro, G. Cristinzio, A. Zoina and D. Russo. (2016), 'Shedding Light on the Effects of Climate Change on the Potential Distribution of Xylella Fastidiosa in the Mediterranean Basin', Biological invasions Vol. 18, No. 6, pp. 1759-1768.

Brito, Dinis, P. Moutinho and Correia. (2019), 'Drought Stress Effects and Olive Tree Acclimation under a Changing Climate', Plants (Basel) Vol. 8, No. 7, pp. 232.

Bronzini de Caraffa, V., J. Giannettini, C. Gambotti and J. Maury. (2002), 'Genetic Relationships between Cultivated and Wild Olives of Corsica and Sardinia Using Rapd Markers', Euphytica Vol. 123, No. 2, pp. 263-271.

Clark, L. F. and W. A. Kerr. (2017), 'Climate Change and Terroir : The Challenge of Adapting Geographical Indications', The Journal of world intellectual property Vol. 20, No. 3-4, pp. 88-102.

Fraga, H., J. G. Pinto and J. A. Santos. (2020), 'Olive Tree Irrigation as a Climate Change Adaptation Measure in Alentejo, Portugal', Agricultural water management Vol. 237, pp. 106193.

Fraga, H., J. G. Pinto, F. Viola and J. A. Santos. (2019), 'Climate Change Projections for Olive Yields in the Mediterranean Basin', International journal of climatology Vol. 40, No. 2, pp. 769-781.

Fullgrabe, L., P. Grosjean, S. Gobert, P. Lejeune, M. Leduc, G. Engels, P. Dauby, P. Boissery and J. Richir. (2020), 'Zooplankton Dynamics in a Changing Environment: A 13-Year Survey in the Northwestern Mediterranean Sea', Marine environmental research Vol. 159, pp. 104962-104962.

Garbolino, E., V. Sanseverino-Godfrin and G. Hinojos-Mendoza. (2016), 'Describing and Predicting of the Vegetation Development of Corsica Due to Expected Climate Change and Its Impact on Forest Fire Risk Evolution', Safety science Vol. 88, pp. 180-186.

Gobert, S., L. Fullgrabe, F. Quentin, M. Leduc, M. Marengo, M. Patrissi, A. Donnay, L. Iborra, J. Richir, M. Garrido and P. Lejeune. (2019), 'Climate Change Impact on Water Column in Corsica', (Ed.)^(Eds.).
———. (2019), 'Climate Change Impact on Water Column in Corsica', (Ed.)^(Eds.).

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Jacob, D IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp., J. Petersen, B. Eggert, A. Alias, O. B. Christensen, L. M. Bouwer, A. Braun, A. Colette, M. Déqué, G. Georgievski, E. Georgopoulou, A. Gobiet, L. Menut, G. Nikulin, A. Haensler, N. Hempelmann, C. Jones, K. Keuler, S. Kovats, N. Kröner, S. Kotlarski, A. Kriegsmann, E. Martin, E. van Meijgaard, C. Moseley, S. Pfeifer, S. Preuschmann, C. Radermacher, K. Radtke, D. Rechid, M. Rounsevell, P. Samuelsson, S. Somot, J.-F. Soussana, C. Teichmann, R. Valentini, R. Vautard, B. Weber and P. Yiou. (2013), 'Euro-Cordex: New High-Resolution Climate Change Projections for European Impact Research', Regional environmental change Vol. 14, No. 2, pp. 563-578.

Marco, M., T. Giacomo, F. Roberto, B. Giada, D. Camilla, M. A. Caspar, L. Marta Mariotti and B. Marco. (2013), 'Olive Trees as Bio-Indicators of Climate Evolution in the Mediterranean Basin', Global ecology and biogeography Vol. 22, No. 7/8, pp. 818-833.

Marescotti, A., X. F. Quiñones-Ruiz, H. Edelmann, G. Belletti, K. Broscha, C. Altenbuchner, M. Penker and S. Scaramuzzi. (2020), 'Are Protected Geographical Indications Evolving Due to Environmentally Related Justifications? An Analysis of Amendments in the Fruit and Vegetable Sector in the European Union', Sustainability (Basel, Switzerland) Vol. 12, No. 9, pp. 3571.

Michalopoulos, G., K. A. Kasapi, G. Koubouris, G. Psarras, G. Arampatzis, E. Hatzigiannakis, V. Kavvadias, C. Xiloyannis, G. Montanaro, S. Malliaraki, A. Angelaki, C. Manolaraki, G. Giakoumaki, S. Reppas, N. Kourgialas and G. Kokkinos. (2020), 'Adaptation of Mediterranean Olive Groves to Climate Change through Sustainable Cultivation Practices', Climate (Basel) Vol. 8, No. 4, pp. 54.

———. (2020), 'Adaptation of Mediterranean Olive Groves to Climate Change through Sustainable Cultivation Practices', Climate (Basel) Vol. 8, No. 4, pp. 54.

Montanaro, G., V. Nuzzo, C. Xiloyannis and B. Dichio. (2018), 'Climate Change Mitigation and Adaptation in Agriculture: The Case of the Olive', Journal of water and climate change Vol. 9, No. 4, pp. 633-642.

Mouillot, F., J.-P. Ratte, R. Joffre, D. Mouillot and a. Serge Rambal. (2005), 'Long-Term Forest Dynamic after Land Abandonment in a Fire Prone Mediterranean Landscape (Central Corsica, France)', Landscape ecology Vol. 20, No. 1, pp. 101-112.

———. (2005), 'Long-Term Forest Dynamic after Land Abandonment in a Fire Prone Mediterranean Landscape (Central Corsica, France)', Landscape ecology Vol. 20, No. 1, pp. 101-112.

Médail, F. (2017), 'The Specific Vulnerability of Plant Biodiversity and Vegetation on Mediterranean Islands in the Face of Global Change', Regional environmental change Vol. 17, No. 6, pp. 1775-1790.

———. (2017), 'The Specific Vulnerability of Plant Biodiversity and Vegetation on Mediterranean Islands in the Face of Global Change', Regional environmental change Vol. 17, No. 6, pp. 1775-1790.

'New Climate Change Findings Reported from University of Tras-Os-Montes and Alto Douro (Climate Change Projections for Olive Yields in the Mediterranean Basin)'. (2019), Global Warming Focus, pp. 73.

Ponti, L., A. P. Gutierrez, P. M. Ruti and A. Dell'Aquila. (2014), 'Fine-Scale Ecological and Economic Assessment of Climate Change on Olive in the Mediterranean Basin Reveals Winners and Losers', Proceedings of the National Academy of Sciences - PNAS Vol. 111, No. 15, pp. 5598-5603.

———. (2014), 'Fine-Scale Ecological and Economic Assessment of Climate Change on Olive in the Mediterranean Basin Reveals Winners and Losers', Proceedings of the National Academy of Sciences - PNAS Vol. 111, No. 15, pp. 5598-5603.

Proietti, S., P. Sdringola, U. Desideri, F. Zepparelli, A. Brunori, L. Ilarioni, L. Nasini, L. Regni and P. Proietti. (2014), 'Carbon Footprint of an Olive Tree Grove', Applied energy Vol. 127, pp. 115-124.

———. (2014), 'Carbon Footprint of an Olive Tree Grove', Applied energy Vol. 127, pp. 115-124.

Tanasijevic, L., M. Todorovic, L. S. Pereira, C. Pizzigalli and P. Lionello. (2014), 'Impacts of Climate Change on Olive Crop Evapotranspiration and Irrigation Requirements in the Mediterranean Region', Agricultural water management Vol. 144, pp. 54-68.

Vaiciulyte, S., E. R. Galea, A. Veeraswamy and L. M. Hulse. (2019), 'Island Vulnerability and Resilience to Wildfires: A Case Study of Corsica', International journal of disaster risk reduction Vol. 40, pp. 101272.

Varela, V., D. Vlachogiannis, A. Sfetsos, S. Karozis, N. Politi and F. Giroud. (2019), 'Projection of Forest Fire Danger Due to Climate Change in the French Mediterranean Region', Sustainability (Basel, Switzerland) Vol. 11, No. 16, pp. 4284.

Vella, M.-A., V. Andrieu-Ponel, J. Cesari, F. Leandri, K. Pêche-Quilichini, M. Reille, Y. Poher, F. Demory, D. Delanghe, M. Ghilardi and M.-M. Ottaviani-Spella. (2019), 'Early Impact of Agropastoral Activities and Climate on the Littoral Landscape of Corsica since Mid-Holocene', PloS one Vol. 14, No. 12, pp. e0226358-e0226358.