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Socio-economic local effects of extreme windstorms in Europe: the case of Vaia, in Italy

Supervisor: Prof.ssa Laura Secco

Co-Supervisor: Federica Romagnoli

PhD Candidate LERH Doctoral School, 3rd year

Candidate: Francesca Donà

Registr. number: 1190688

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SUMMARY

Among the different types of extreme weather events affecting Europe, windstorms represent the second biggest threat in terms of frequency, severity and economic impact, accounting for the 25% of Europe's economic losses due to climate hazards.

What are the effects of such extreme weather events on the local dimension?

This question represents the leitmotif of this work, which aims at researching how windstorms can influence the dynamics of the social, institutional and economic spheres of the affected territories, and their local development.

The work tries to shed light on the role played by national and regional public institutions, private companies and local communities within the decision-making processes related to windstorm risk management. Further, it has been investigated the role of key stakeholders involved in the implementation of adaptation strategies, focusing on strengths and challenges – especially in the forestry dimension, as it is one of the more exposed to windstorm risks.

To achieve this goal two methodologies have been implemented: a literature analysis and a primary data collection on post-windstorm economic trends. The former searches for good practices and management approaches to deal with windstorms at the local level through the analysis of four European case studies; the latter focuses on the investigation of possible economic effects of Vaia windstorm, that in 2018 hit the North-east of Italy.

In the first case, despite the limited available literature, the analysis returned interesting insights for discussion regarding: i) the role of social capital, ii) different institutional responses and iii) economic mechanisms for post-windstorm management. The second analysis highlighted the limited availability of comparable data at the local level in the study area selected, that did not allow establishing with confidence a causal relationship between the windstorm and the economic trends analysed. Despite such limitations, it was possible to observe innovations and valuable approaches within each of the case study examined. Furthermore, what is most relevant to emphasise is that all responses implemented which have been studied, were stemming from the specificities of the local dimensions.

Then, the greatest challenges detected within post- windstorm management concern the development of institutional capacities, the inclusion of local actors in policy-making processes, and the availability of locally comparable data for the improvement of windstorm management approaches.

On the basis of these results, the research conclusions stress the importance of knowing and correctly interpreting the key features of the local dimension, especially in the perspective of implementing post-windstorm strategies that boost territorial development and strengthen relational and collaborative networks between the wide variety of actors within the territory.

SUMMARY – Italian version

Tra le diverse tipologie di eventi climatici estremi che colpiscono l'Europa, le tempeste da vento rappresentano la seconda più grande minaccia in termini di frequenza, severità ed impatto economico, costituendo il 25% delle perdite economiche Europee dovute ad eventi climatici estremi. Quali sono gli effetti che tali eventi climatici comportano nella sfera locale?

Questa domanda rappresenta il fil-rouge del presente lavoro, che si propone di ricercare come le tempeste da vento possono influenzare le dinamiche della sfera sociale, istituzionale ed economica dei territori colpiti, ed il loro sviluppo locale.

In particolare, si cerca di far luce sul ruolo svolto dalle istituzioni pubbliche nazionali e regionali, dalle aziende private e dalle comunità locali all'interno dei processi decisionali relativi alla gestione dei rischi da tempeste da vento. Inoltre, è stato analizzato il ruolo dei principali stakeholders coinvolti nell'attuazione delle strategie di adattamento, con focus specialmente sull'analisi dei punti di forza e delle sfide emergenti - in particolare nella dimensione forestale, che è una delle più esposte ai rischi delle tempeste di vento.

Per raggiungere questo obiettivo sono state implementate due metodologie: un'analisi della letteratura ed una raccolta di dati primari sulle tendenze economiche post tempesta.

La prima ricerca le buone pratiche e gli approcci gestionali per affrontare le tempeste di vento a livello locale attraverso l'analisi di quattro casi di studio europei; la seconda si concentra sull'indagine dei possibili effetti economici della tempesta di vento Vaia, che nel 2018 ha colpito il Nord-Est dell'Italia.

Nel primo caso, nonostante la limitata letteratura disponibile, l'analisi ha restituito interessanti spunti di discussione riguardanti: i) il ruolo del capitale sociale, ii) le diverse risposte istituzionali e iii) i meccanismi economici per la gestione del post- tempesta. La seconda analisi ha evidenziato la limitata disponibilità di dati comparabili a livello locale nell'area di studio selezionata, che non ha permesso di stabilire con certezza una relazione causale tra la tempesta e le tendenze economiche. Nonostante tali limitazioni, è stato possibile osservare innovazioni e approcci validi in ciascuno dei casi di studio esaminati. Inoltre, l'aspetto più rilevante da sottolineare è che tutte le risposte analizzate, derivano dalla specificità delle dimensioni locali. Le maggiori sfide rilevate nell'ambito della gestione post-tempesta riguardano lo sviluppo delle capacità istituzionali, l'inclusione degli attori locali nei processi decisionali e la disponibilità di dati comparabili a livello locale per il miglioramento degli approcci e strategie territoriali.

Sulla base di questi risultati, le conclusioni della ricerca sottolineano l'importanza di conoscere e interpretare correttamente le caratteristiche chiave della dimensione locale, soprattutto nella prospettiva di implementare strategie post-tempesta che diano impulso allo sviluppo territoriale e rafforzino le reti relazionali e collaborative tra l'ampia varietà di attori presenti sul territorio.

1. INTRODUCTION

Among the big challenges of our century, climate change and climate crises are now largely taking the lead throughout the worldwide scenario, shading light on the impellent need to collectively handle such a complex matter.

Compared to the pre-industrial period, global climate has changed and there are multiple evidences showing that such changes are already heavily impacting ecosystems and organisms all over the world, as well as human systems and human well-being (e.g. UN, 2005; UNFCC, 2015; IPCC, 2018).Within this framework, it is important to highlight that the so-called phenomenon of climate change is not only referring to those cyclical meteorological events which are physiological adjustments of the environment, but it also includes an anthropogenic component. There is indeed robust evidence (Meadows et al.,1972; Gardiner et al., 2013; UNFCC, 2015; UNDP,2016; EEA, 2017; IPCC, 2018) proving that since the era of industrialization, human's deregulated activities have induced tangible changes in climate such as the increase of temperatures in both land and oceans, resulting in more frequent and longer-lasting heatwaves throughout land regions and within the marine ecosystems.

Furthermore, it has been verified that the increase in frequency, intensity and amount of heavy precipitation phenomena at the global scale is tightly related to the above mentioned human activities (Meadows et al., 1972; UNFCC, 2015; IPCC, 2018).

One of the major pieces of evidence associated with climate change is the intensification - both in terms of occurrence and intensity - of extreme weather phenomena such as floods, windstorms, droughts, heatwaves, wildfires, etc. (IPCC, 2018; UNDP, 2016; EEA, 2017).

In fact, between 1980 and 2016, the total recorded economic losses caused by climate and weather-related extreme events in the 33 EEA member countries amounted to €450 billion.

Of this sum, windstorms represent the second most dangerous threat in Europe in terms of frequency, severity, and economic impact, accounting for the 25% of all European economic losses due to climatic hazards (EEA, 2017).

European windstorms are a high-impact weather phenomenon, regularly inflicting substantial damages to the human, environmental and economic spheres: the risk for wind damage in both human and natural systems is expected to increase in the next decades (Roberts et al.,2014; Forzieri et al.,2020), mainly as consequence of an increase in exposure and vulnerability of more and more fragile ecosystems and communities. Indeed, another alarming aspect is the beginning of the occurrence of such phenomena in unusual geographical areas, whose societies do not have the necessary operational knowledge needed to manage such extreme events, calling therefore for the shaping of new mitigation and adaptation policies aimed at limiting the increase in exposure and vulnerability of the human and natural systems concerned (Schelhaas et al.,2010).

Despite the potential threats envisaged, the research field studying windstorms is relatively new within the European community: this subject has gained serious attention only in the last two decades, after the occurrence of some exceptionally extreme windstorms at the end of the 90s like Daria in 1990 and Lothar in 1999, each of which caused around 100 fatalities and more than US$ 8 billion in insured losses, highlighting the urgency of better studying these phenomena so that adequate adaptation and mitigation policies can be designed and set in place (Berz, 2005).

However, while many studies have been focusing on the global or large-scale windstorms dynamics, research is actually facing bottlenecks within the regional and small-scale study, mainly because this interest in investigating European windstorms at small-scale level is quite recent and so the possibility of comparing present data with antecedent periods actually represents a methodological challenge (Ummenhofer and Meehl, 2017).

Since for the end of the century an intensification of such extreme phenomena is envisaged, (Roberts et al.,2014), there are no European areas totally safe from being affected by such extreme events. As previously mentioned, while some societies are already accustomed to live with windstorms and are prepared for them, others are actually lacking the operational and structural tools for dealing with such violent events (EEA,2017).

The broad emerging picture is that the range of exposure and vulnerability to windstorms' hazards is very wide across Europe, and it is for such reason that one of the main aims of this work is finding out and deepen various institutional and socioeconomic measures applied in the past in different contexts and aimed at facing the challenges posed by such potential threats through adaptation and mitigation actions (Berz, 2005), to extract lessons to learn.

Thus, the focus of the work is particularly centred on the research and analysis of the interactions occurring within the local sphere, since as a large number of studies on the subject is dealing with the topic from a point of view macro (Caurla et al., 2015), the intention of this analysis is to search for complementary informative insights concerning also the interactions' dynamics occurring at the local level.

In light of the fact that it is mostly the local dimension that is at the forefront of the management of these extreme climatic phenomena (Gardiner et al.,2013), particular attention is paid towards the search of tools and approaches enforcing a developmental model which has a local and adaptive focus, and stems from the specificities of the territories, communities and the broad range of institutional and economic bodies involved.

Just as the level of exposure and vulnerability varies between different territories, the same is also true for the effects of windstorms: for this reason, the present work aims at studying the dynamics of the local dimension. Given that local development can be a highly uneven process, and depending on the territory and its resources it can produce different social, institutional and economic outcomes (Bizikova et al.,2007), adopting a local focus within the analysis helps to understand how the organisation of adaptation and mitigation processes is formed and how it evolves, as well as allowing to assess what types of social, institutional or economic innovations may emerge in a specific context, and these virtuous mechanisms can then be detected and transformed into good practices that could be shared with communities and contexts exposed to the same types of risks and hazards.

Therefore, studying the local dynamics of management and adaptation to the effects of windstorms is crucial for improving the efficiency and the quality of policy-making processes and the frameworks for actions, because unfortunately large-scale studies often fail to take into account the local and place-based specificities of societies and environmental contexts (Caurla et al., 2015).

This limited knowledge of local detail tends then to reduce the understanding of the impacts of extreme climatic events, as well as the responsiveness and active participation within policy-making processes (Brennan et al., 2005), hindering the formulation of adequate adaptive local development policies.

In fact, some local key-actors may be put into a marginalised position within the decision-making dynamics and so their potential may be not valorised enough as a key-resource for the improvement of these mechanisms.

Whereas, analysing the local-scale dynamics could complement this information gap and provide useful suggestions on how to include local development thinking and territorial policies within the policy making processes, in order to assist with the creation of local pathways to increase the opportunities and capacity for effective mitigation and adaptation to windstorms (Brennan et al., 2005).

To this end, particular attention is paid on the analysis of the forestry dimension: since it represents one of the sectors with the greatest exposure to the risks and effects of windstorms (EEA, 2017), it constitutes one of the most interesting areas for the analysis of the potential and challenges posed by windstorms at the local level, as forests represents a resource of vital importance both for socio-economic and environmental conservation goals.

Indeed, the damages that windstorms cause to our forests have critical socio-economic ed environmental consequences, especially for those local economies and communities who are highly dependent on the forest sector activities and services (Forzieri et al., 2020).

The need of shading light on such complex and little explored topics takes its move precisely from a recent heavy windstorm known as Vaia, which in October 2018 hardly hit southern Alps, mostly the whole North-East of Italy, destroying more than 8.5 million cubic meters of wood and largely devastating both the alpine forests and ecosystems and infrastructures.

Forests represent a fundamental resource for the balance of human and natural systems, especially because they provide a number of ecosystem services that are essential for the resilience of local communities, such as protection from natural hazards like avalanches or landslides, which could threaten infrastructures and settlements, or also, employment opportunities and products that are important for the local economy, such as tourism (UNDP, 2016; IPCC, 2018; Forest Europe Report, 2020)

Forests are reservoirs of biodiversity and mitigate climate change: such systems play an essential role in the enhancement of the landscape and its nature, which is why it is important to study and deepen their potential and challenges at the local level so that they can be preserved in an efficient and sustainable manner (IPCC, 2018; Forest Europe Report, 2020).

Within this contest of complex multi-level dynamics, this research work is then attempting to provide a contribution in deepen such key matters, by means of a literature review concerning some of the extreme phenomena that hit Europe during the last 20 years ca. and analysing and comparing the methodologies and best practices offered by the management approaches applied locally, for the different windstorm examined.

Specifically, this thesis addresses three main research objectives:

1. to provide and systematize insights concerning the main features of windstorm events, their evolutional trend, the related effects on the institutional and socioeconomic spheres at the local level and the main theoretical frameworks adopted to cope with such climatic challenges;
2. to identify and extract lessons to learn about good practices and methodological frameworks that can help to improve the ways to approach and manage windstorms consequences in European contexts;
3. to identify possible local socio-economic effects of windstorms, through a descriptive statistical research dealing with the windstorm Vaia that hit five regions in the North-East of Italy in October 2018.

The study tries to shed light on the role played by national and regional public institutions, private companies and local communities within the decisional process concerning disaster risk management, as well as on different solutions, i.e. systems set in place, with their potentialities and challenges, to foster resilience and adaptation strategies and tools that might be effective at local level, with a special focus on the forest-related systems.

For what concerns the thesis structure, it is divided into six chapters.

An introductive part briefly introduces the origins of climate change discourse while presenting the topic of European windstorms and their features, highlighting the main challenges posed by such phenomena over the European territories.

Then the first chapter introduces and describes the methodological approaches used within the analysis, namely a literature review and a primary data collection involving the case study of windstorm Vaia in Italy.

The second chapter (background section) presents the most frequent analytical frameworks used in literature to investigate extreme climate events, offering some insights on the theoretical approaches and strategic tools aimed at improving the decisional processes concerning the adaptation and mitigation policies towards windstorm occurrence.

The third chapter deals with the literature review of four cases of extreme windstorms which hit Europe between 1999 and 2018, namely Lothar, Gudrun, Klaus and Vaia, describing the findings and observations for each case study according to the main areas of interest, namely the social, institutional and economic dimensions.

The fourth chapter follows, which is dedicated to the comparison of the four case studies selected, divided into the three main dimensions above mentioned.

The fifth chapter is devoted to the presentation of the descriptive statistical research dealing with the effects of windstorm Vaia within the economic dynamics at the local level, starting from an in-depth analysis of the sectorial entrepreneurial trends of the affected regions.

Then the sixth chapter deals with the assessment and description of the methodological and operational limits found within the analytical process.

The seventh chapter points out the detected limits and challenges detected within both the research methodologies.

Lastly, the concluding part is taking up the major findings obtained from the literature review and the statistical study on the Vaia windstorm, trying to identify the main key points for better understanding and analysing this type of phenomena and lessons to be learned.

2. METHODOLOGY

In order to organize efficiently the research process dealing with such a multifaceted and, above all, little explored topic, the methodology of the present work is structured around two different types of approaches: the first, an analysis of the available literature concerning the management of European windstorms among the forestry sector, while the second, a descriptive statistical study looking for the possible socio-economic effects of storm Vaia within the local dimension of north-eastern regions of Italy, severely affected during its passage in October 2018.

These methodological approaches are aimed at fostering a collection of observations and information that can allow to understand, on a general level, the social, institutional and economic implications of windstorms in Europe, while on a specific level, which effects of windstorms can be found within the local dimension of these three dimensions, and which types of strategies and risk management approaches can be designed.

2.1 LITERATURE REVIEW

The first approach, the literature review, makes use of scientific articles selected via the Google Scholar and Scopus search engines, through a targeted keywords search. The aim of this first phase is to obtain both papers that provide a general overview of the characteristics and possible consequences of windstorms over Europe, and papers that examine in depth how these extreme events affect society, institutions and the economy, especially within the local dimension, paying particular attention towards the dynamics involving the forestry sector. Once the papers needed to establish the general framework of extreme windstorm management and the European forestry dynamics have been selected, the search focus turned to the choice of the papers needed to investigate what these extreme phenomena imply on the local territorial scale. The research focus is put on the local dimension, especially on the study of the dynamics of reaction and interaction between local communities, civil society, local entrepreneurs and territorial institutions.

At the methodological level, it was decided to search for case studies of extreme windstorms with similar characteristics in order to be able to study the management approaches set in place and the territorial effects on the one hand, while on the other, where possible, analysing and comparing how different countries have acted to respond to similar windstorms. In addition, given that the research aims also at analysing windstorm effects on European forests, particular attention is paid towards studies dealing with the management of the forestry dimension and the closely related sectors.

Considering that statistically northern and central European countries are more affected by extreme windstorms (Hoskins and Hodges, 2002), an important part of the selected bibliography presents studies carried out in these geographical areas.

However, since one of the methodological objectives of the review is also to include European geographical areas less prone to extreme windstorms, for the four windstorms examined that struck Europe between 1999 and 2018, respectively Lothar (1999), Gudrun (2005), Klaus (2009) and Vaia (2018), two cases involve countries where these climatic occurrences are more frequent - Lothar in Germany and Switzerland, and Gudrun in Sweden - and two cases, on the other hand, involve geographical areas where extreme windstorms have been (so far) rather rare events, namely France for storm Klaus and Italy for storm Vaia.

For what concerns the selection criteria for the case studies of extreme windstorms, the wind gusts' measured speed has been individuated as the common criterion for the case study selection, as when a windstorm's wind speed exceeds the 25 m/s threshold, this feature classifies the climatic event as severely damaging (Roberts et al., 2014).

The selected windstorms with their wind speed specifications, geographic extent and date of occurrence are illustrated in the following *table 1*. This selection criterion is significant for the analysis' implementation because all storms, being classified as extremely impactful events, are involving not only the natural systems but also the human systems, allowing for an in-depth analysis of how different states respond, starting from the same level of emergency.

WINDSTORM NAME	OCCURRENCE DATE	INVOLVED COUNTRIES	MAX WIND SPEED
Lothar	1999	**Germany**, France, Belgium, Switzerland	259 km\h
Gudrun	2005	**Sweden**, Norway, Denmark, Ireland, Uk	>180 km\h
Klaus	2009	**France**, Spain, Andorra, Italy	190 km\h
Vaia	2018	**Italy**, Switzerland, Austria, Slovenia	>200 km\h

Table 1. *Case studies considered within the analysis and their main identifying information such as geographical extension, occurrence date and max wind speed detected. (In bold, the most affected country)*

Once the papers were selected, all available information concerning the social, institutional and economic component were identified in the text through qualitative-based content analysis techniques, and extracted and elaborated for each case study, trying to understand which methods, strategies and tools were adopted from time to time, and which kind of dynamics can

be observed among the involved actors, depending on the geographical area involved, to deal with the different emergency situations and what lessons could be learned in this regard.
In order to better monitor the possible evolutions of detected approaches and strategies, the case studies are presented in chronological order.
After the presentation of the various extreme windstorm scenarios and the related response in their aftermath, the approaches and dynamics investigated are discussed according to the related sphere of interest in order to highlight the emerging information and observations.

2.2 PRIMARY DATA COLLECTION OF SOCIO-ECONOMIC EFFECTS OF WINDSTORM VAIA IN ITALY

For what concerns the second methodological approach of this work, the present descriptive statistical study deals with a tentative identification of socio-economic effects of windstorm Vaia in north-eastern Italy and it was carried out within the framework of the project "Vaia Front" at the TESAF Department of the University of Padova during the academic year 2020\2021.
The primary objective of this descriptive statistical research is to investigate the possible effects of windstorm Vaia within the economic dynamics at the local level, starting from an in-depth analysis of the sectorial entrepreneurial structures of the five affected Italian regions, namely Trentino Alto Adige, Veneto, Friuli Venezia Giulia and Lombardy, focusing in particular on the gathering and comparison of data concerning the birth-mortality rate of companies and businesses within the Vaia's affected areas.
Specifically, since the study is aimed at achieving a comprehensive vision of the sectorial trends before and after the windstorm, it has taken into account the sectors considered as the most exposed and vulnerable in the face of an extreme event of this magnitude, from the economic point of view. All the relevant economic sectors involved with the study are indicated in *table 2* with their respective ATECO identification code.

REFERENCE SECTOR	**ATECO ID CODE**
Silviculture and use of forestry areas	02.1 ; 02.2
Agriculture and production of animal products	01
Manufacture	Section C
Construction	F41 ; F42 ; F43
Accommodations	I55

Catering	I56
Energy supply services	Section D

Table 2. *Reference sectors used within the statistical analysis of Vaia's case study*

The choice to include several sectors within the analysis was made with the aim of seeking an analytical approach that could provide a holistic view of the effects of the windstorm on the economy at local level on these Italian regions and provinces. At the same time, the selected sectors of interest also represent the economic areas in which one would expect to see a change in the birth-mortality rate of companies, as these areas could be directly affected by extreme windstorms, both positively, e.g. in terms of new opportunities in the post-event phase, and negatively, e.g. in terms of high costs due to the need of recovery from damages and vulnerability and exposure to future risks.

However, the approach of this primary data collection study intended to examine possible significant variations among the birth-mortality rate of regional and provincial businesses of the selected economic sectors taking a short-term timeframe as the time reference for comparison, starting from the period before the windstorm, 2017, then considering the year of the climatic event itself, 2018, and finally, assessing the trends for the following year, 2019.

Such short-term timeframe has been selected for two main reasons, namely 1) to be able to gather complete time series of data for all regions and years of interest, which had to be also homogeneous so to this end, every possible limitation of available databases had to be taken into account carefully and 2) to try to avoid the detection of other drivers of change unrelated to the windstorm.

In addition, the study of the information collected was divided as well into several levels: it was decided to highlight two very precise frameworks for research and data comparison – regional and provincial, respectively – in order to increase the chances of detecting local changes within the economic systems that might having been associated to the effects of the windstorm Vaia. However, the analysis is not intended as an impact evaluation; rather, it allows identify general trends of changes from 2017 to 2019, which might be partially explained by the Vaia event, since this was the most dramatic punctual event hitting similarly all of the five different regions.

In order to test the guiding hypothesis effectively and consistently, the activities carried out in order to obtain the data were divided into four distinct phases, namely: data searching, data collection, data processing and data analysis.

As far as the first phase is concerned, the search for possible databases took place during the autumn of the academic year 2020\2021. Through the Google search engine, the research was

carried out with targeted keywords in order to obtain an initial collection of databases and data platforms to be analysed and selected.
Then the focus was put on looking for updated databases, statistical archives, observatories, providing for comparable information relating to the reference period of the study.
Among the many databases taken into consideration, there were both data archives on a national level such as ISTAT, Movimprese or the economic reports of the Bank of Italy, as well as data archives on a regional level such as the *Annuario Statistico Regionale* of Lombardy or the *Sistema Statistico Regionale* of Veneto.Finally, the national platform Movimprese was selected, as of all those examined, it was the only dataset capable of providing complete data both from a regional and provincial point of view, as well as in terms of comparability, and above all, in accordance with the reference timeline. Specifically, the Movimprese tool encompasses the statistical analysis conducted by Infocamere concerning the birth-mortality rate of enterprises in the national territory and is based on the archives of all Italian Chambers of Commerce (Movimprese, 2021).
Therefore, it represented an extremely useful and facilitating information source for the completion of the data collection phase.
From this platform, data was then extracted for each sector of interest indicated in the section above, and the total number of businesses duly registered in the Business Register that were active or ceased between 01.01.2017 and 31.12.2019 was gathered within the analysis' dataset.
Subsequently, the data were transcribed within a dataset in Windows Excel, grouped into clusters at the regional level in order to obtain a broader view of the trend in the status of activities, but also in more detail, reporting the number of active and ceased businesses between 2017 and 2019 for each province of the four regions under review, as shown in *fig. 1.*
To obtain data on the percentage distribution of active and ceased enterprises in the various sectors in the various provinces, the total number of active and ceased enterprises from the Movimprese platform was first calculated. From this data, the total number of active and ceased enterprises was then calculated, and to calculate the percentage distribution, for each province and sector considered, the number of active or ceased enterprises was divided by the total number of enterprises, and then multiplied by one hundred.
Once the transcription of the data was completed, a series of tables was then created in order to be able to move on to the processing phase of the collected information: the data was grouped by type of sector of interest, region, province, year and finally, status of activity of the companies.

REGIONE	PROVINCIA	ANNO	SETTORE PRIMARIO	STATO	TOTALE (imprese)
trentino alto adige	bolzano	2017	silvicoltura e utilizzo aree forestali	cessate	17
trentino alto adige	bolzano	2018	silvicoltura e utilizzo aree forestali	cessate	12
trentino alto adige	bolzano	2019	silvicoltura e utilizzo aree forestali	cessate	15
trentino alto adige	trento	2017	silvicoltura e utilizzo aree forestali	cessate	10
trentino alto adige	trento	2018	silvicoltura e utilizzo aree forestali	cessate	15
trentino alto adige	trento	2019	silvicoltura e utilizzo aree forestali	cessate	16
friuli venezia giulia	gorizia	2017	silvicoltura e utilizzo aree forestali	cessate	3
friuli venezia giulia	gorizia	2018	silvicoltura e utilizzo aree forestali	cessate	0
friuli venezia giulia	gorizia	2019	silvicoltura e utilizzo aree forestali	cessate	1
friuli venezia giulia	pordenone	2017	silvicoltura e utilizzo aree forestali	cessate	5
friuli venezia giulia	pordenone	2018	silvicoltura e utilizzo aree forestali	cessate	6
friuli venezia giulia	pordenone	2019	silvicoltura e utilizzo aree forestali	cessate	5
friuli venezia giulia	trieste	2017	silvicoltura e utilizzo aree forestali	cessate	0
friuli venezia giulia	trieste	2018	silvicoltura e utilizzo aree forestali	cessate	0
friuli venezia giulia	trieste	2019	silvicoltura e utilizzo aree forestali	cessate	0
friuli venezia giulia	udine	2017	silvicoltura e utilizzo aree forestali	cessate	13
friuli venezia giulia	udine	2018	silvicoltura e utilizzo aree forestali	cessate	18
friuli venezia giulia	udine	2019	silvicoltura e utilizzo aree forestali	cessate	20
veneto	belluno	2017	silvicoltura e utilizzo aree forestali	cessate	14
veneto	belluno	2018	silvicoltura e utilizzo aree forestali	cessate	18
veneto	belluno	2019	silvicoltura e utilizzo aree forestali	cessate	18
veneto	padova	2017	silvicoltura e utilizzo aree forestali	cessate	0
veneto	padova	2018	silvicoltura e utilizzo aree forestali	cessate	1
veneto	padova	2019	silvicoltura e utilizzo aree forestali	cessate	4
veneto	rovigo	2017	silvicoltura e utilizzo aree forestali	cessate	0
veneto	rovigo	2018	silvicoltura e utilizzo aree forestali	cessate	2
veneto	rovigo	2019	silvicoltura e utilizzo aree forestali	cessate	4
veneto	treviso	2017	silvicoltura e utilizzo aree forestali	cessate	5
veneto	treviso	2018	silvicoltura e utilizzo aree forestali	cessate	2
veneto	treviso	2019	silvicoltura e utilizzo aree forestali	cessate	3
veneto	venezia	2017	silvicoltura e utilizzo aree forestali	cessate	0
veneto	venezia	2018	silvicoltura e utilizzo aree forestali	cessate	0
veneto	venezia	2019	silvicoltura e utilizzo aree forestali	cessate	2
veneto	vicenza	2017	silvicoltura e utilizzo aree forestali	cessate	9
veneto	vicenza	2018	silvicoltura e utilizzo aree forestali	cessate	3

Fig.1 *Table created for the data analysis of the birth-mortality of enterprises in the 5 areas of interest, broken down by region, province, year, sector type and activity status.*

Then, starting from the available tables, the necessary operations were carried out on the data in order to be able to create trend graphs representing the number of active and ceased enterprises in the various sectors.

From the total number of active and ceased enterprises obtained from the Movimprese data platform, the total number of enterprises was calculated - both by province and by region - thanks to which it was then possible to calculate the percentage of ceased enterprises with respect to the total, and the percentage of active enterprises with respect to the total, again according to the two levels of analysis, namely by region and province.

Subsequently, in order to facilitate the analysis phase, two types of histogram graphs were created in Excel: in the first case, the histograms were useful to represent in a regional comparison the distribution's percentage of active and ceased enterprises showing the trends of all targeted sectors, which were then divided into primary, secondary and tertiary sector.

Within the second case, the histogram graphs were used to represent in more detail and depth the distribution's percentage of active and ceased companies over the three-year period of interest by analysing the variation in the data of the individual provinces in each region.
In this case, therefore, the analysis of the information was carried out by proceeding from region to region, creating two graphs respectively, one for active companies and one for terminated companies, for each of the seven sectors examined in the study, as *fig.2* indicates. Therefore, to highlight possible differences between the four regions considered, line graphs were also added to the analysis for having another viewpoint supporting the general data comparison, with the aim of highlighting the trend of active or ceased companies at the level of the various regions, analysed according to the sector of interest, as shown in *fig.3*.

SETTORE	REGIONE	PROVINCIA	ANNO	ATTIVE	CESSATE	TOT	% CESSATE SU TOT	% ATTIVE SU TOT
silvicoltura e utilizzo delle aree forestali	trentino	bolzano	2017	569	17	586	2,9	97,1
silvicoltura e utilizzo delle aree forestali	trentino	bolzano	2018	586	12	598	2,0	98,0
silvicoltura e utilizzo delle aree forestali	trentino	bolzano	2019	602	15	617	2,4	97,6
silvicoltura e utilizzo delle aree forestali	trentino	trento	2017	230	10	240	4,2	95,8
silvicoltura e utilizzo delle aree forestali	trentino	trento	2018	224	15	239	6,3	93,7
silvicoltura e utilizzo delle aree forestali	trentino	trento	2019	231	16	247	6,5	93,5

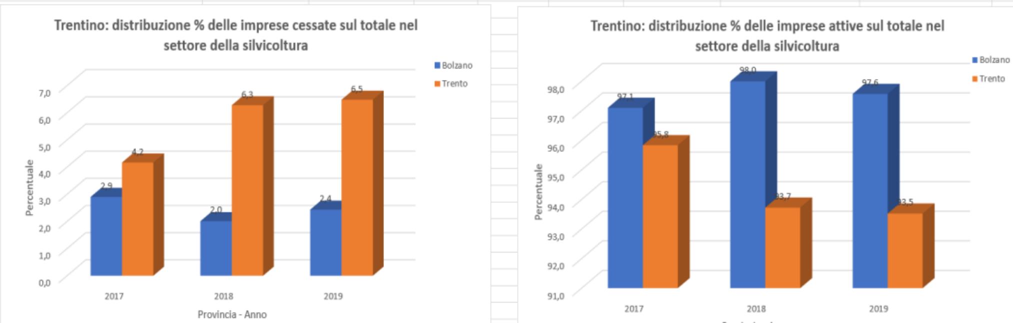


Fig.2 *Example of analysis for individual provinces: histogram table and graph used to represent the percentage distribution of the birth-mortality of enterprises in the sector of Silviculture and use of forestry areas in Trentino between 2017 and 2019.*

SETTORE	REGIONE	ANNO	TOT ATTIVE	TOT CESSATE
agricoltura e produzione di prodotti animali	friuli	2017	13124	679
agricoltura e produzione di prodotti animali	friuli	2018	12955	704
agricoltura e produzione di prodotti animali	friuli	2019	12654	672
agricoltura e produzione di prodotti animali	trentino	2017	27791	929
agricoltura e produzione di prodotti animali	trentino	2018	27863	955
agricoltura e produzione di prodotti animali	trentino	2019	27673	1084
agricoltura e produzione di prodotti animali	veneto	2017	63637	3165
agricoltura e produzione di prodotti animali	veneto	2018	63186	3007
agricoltura e produzione di prodotti animali	veneto	2019	62251	3103
agricoltura e produzione di prodotti animali	lombardia	2017	45098	2198
agricoltura e produzione di prodotti animali	lombardia	2018	44462	2065
agricoltura e produzione di prodotti animali	lombardia	2019	43557	2249

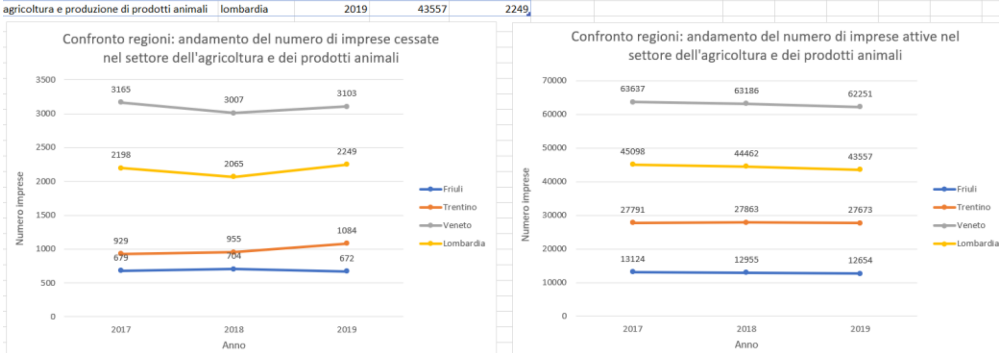


Fig.3 *Example of analysis for sectoral comparison: table and line graph used to represent the trend in the number of active and terminated enterprises in the agriculture and animal products sector of the 4 regions under study.*

3. BACKGROUND: ACKNOWLEDGING CLIMATE EXTREMES

As it emerges from many international scientific studies (Meadows et al. 1972; UNDP, 2016; IPCC,2018), it is clear that since the start of 20th century there has been an increase in mean global temperatures of about 0.6°C, and such raise has allowed experts to assess the evidence of two main shifts in climate tendencies: firstly, it has been observed that the overall raising of temperatures comes in association with a stronger warming in minimum temperatures than in maximum ones, resulting in a reduction of the diurnal temperature range and secondly, it has also been noted that precipitations on land surface have increased over the same period, especially in the mid-to high latitudes.

Furthermore, according to the broad literature concerning climate change management, there has been a focus especially on two specific climatic scenarios, respectively at 1.5° and 2.0° increase, and their related evolutional trends such as increasing temperatures and precipitation phenomena, as shown in *fig.4*, aiming at forecasting – and possibly mitigating – the potential evolution and consequent impacts of such changes within the global ecosystems and human systems.

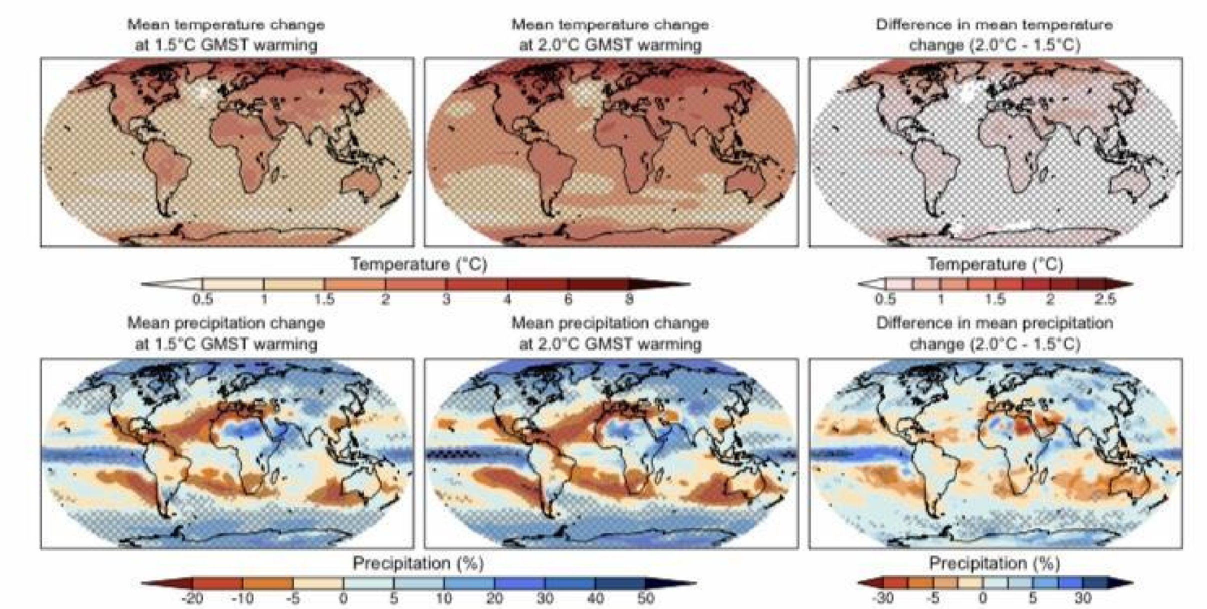


Figure 4. *Projected changes in mean temperature (top) and mean precipitation (bottom) at 1.5°C (left) and 2°C (middle) of global warming compared to the pre-industrial period (1861–1880), and the difference between 1.5°C and 2°C of global warming (right). Source: IPCC Report, 2018, Chapter 3.*

Particularly, such temperature and precipitation extremes have been observed to increase abnormally in both frequency and intensity, and beyond the physiological regulation of climate, letting the evidence of a human-induced contribution in climate change gaining further terrain (IPCC, 2018). It is well known that changes in these aspects resulted in consequent changes in atmospheric events considered as climatic extremes, such as windstorms, hurricanes, heat waves and floods.

But before moving forward, what does exactly mean an "extreme climatic event"? According to the climatological definition given within the framework of the IPCC Special Report on Extreme events released in 2012, an "extreme climatic event" – hereinafter ECE – has been defined as *"the occurrence of a weather or climate variable above (below) a threshold value near the upper (lower) end of the range of observed records of the variable"*: of course, in order to correctly describe an ECE and the related threshold value[1] within the range of observed records, it is important to highlight that they must be defined according to a reference period, which usually is a specific historical time-series (IPCC Report, 2012) and so the choice of the specific reference period will consequently affect the change's assessments and whether it should be considered to be a static or a transitional event.

Moreover, it is also relevant to note that in absolute terms, the conception of what an extreme event is, will vary with reference to the considered area: indeed, the characteristics which describes an ECE are tightly linked to a location's mean climatic condition and its variability (Ummenhofer and Meehl, 2017).

In order to have a better understanding on how ECEs can vary according to the different variables considered, *fig.5* represents the effects of changes in the temperature distribution on ECE occurrence between present and future climate conditions (IPCC Report, 2012) showing respectively:

(a) effects of a simple shift of the entire distribution towards a warmer climate;

(b) effects of an increase in temperature variability with no shift in the mean;

c) effects of an altered shape of the distribution, in this example a change in asymmetry towards the hotter part of the distribution.

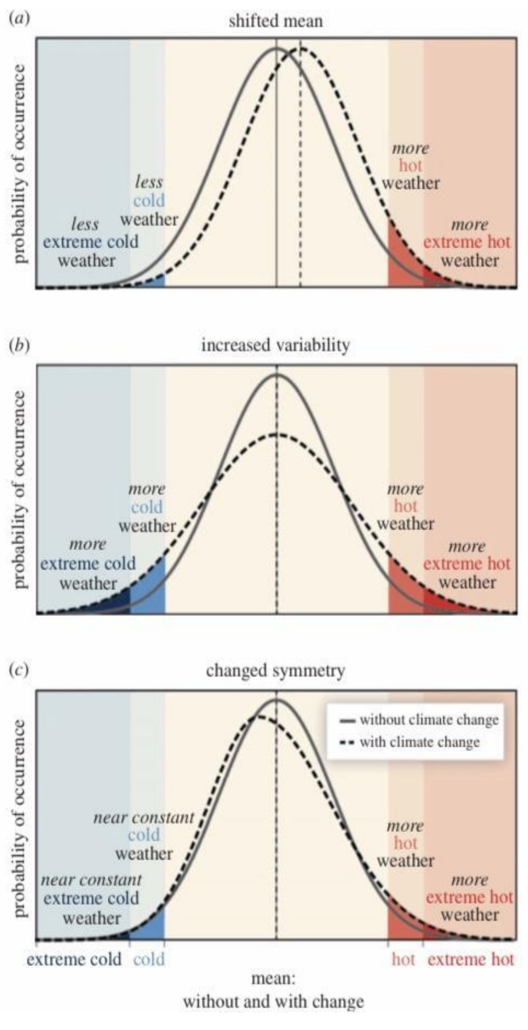


Figure 5. *Variability of ECEs with and without climate change. Source: IPCC Report 2012*

[1] The threshold value that defines an extreme or non-extreme climate event is a structured variable depending on the geographic determination, mean climatic conditions and the records of climate events observed in that specific area. (IPCC Report, 2012)

Additionally, with respect to the study and analysis on ECEs, it is as well important remarking that while counts of threshold exceedance, such as duration and frequency, are tightly following mean changes, variations in intensity or severity are considerably more sensitive to changes in the shape of the probability distribution *(fig. 5)*.

Furthermore, it is also relevant to briefly mention some characteristics of interest useful in observing and describing ECEs, namely their magnitude, the probability or return frequency, the duration and spatial extent, the timing and seasonality and ultimately, the preconditioning, which in this context refers to *"antecedent conditions that facilitate or enable a certain extreme event to occur or modify its characteristics"* (Ummenhofer and Meehl, 2017).

Then, if it is assumed – as aforementioned - that impact-related thresholds varies across space and time, and that in order to define an ECE, it has to be considered with respect to different geographical areas, time periods and their seasonality, it can be then defined quantitatively in two different ways (Roberts et al.,2014):

1. in relation to a specific threshold, possibly impact-related;
2. related to the probability of occurrence.

In order to properly understand the scientific basis of climate change, a reliable detection and attribution of changes in such specific climatic events and their impacts plays a key-role within this research context, being capable of enabling effective processes of decision-making, leading to more performant adaptation and mitigation plans.

And within this context, the action of "detection" is referring to the procedure of demonstrating that a defining feature of an ECE - or a climate variable more broadly - has changed compared to some previous period and it is statistically noticeable (Easterling et al.,2000).

Moreover, there are also several approaches for detection and attribution of a particular event, and they can be classified respectively in two broad categories, firstly the studies using the observational records to verify whether a change in the probability or magnitude of an ECE has occurred and secondly, those studies based on climate model simulations comparing characteristics of the event by using models with and without anthropogenic climate change; a combination of both approaches is also often applied (Ummenhofer and Meehl, 2017).

However, while much research studies are focusing on the global or large-scale dynamics, research activities are facing difficulties within the regional and small-scale study and detection of ECEs dynamics and consequently, also links between small and large-scale processes are little explored, mainly because the interest in investigating ECEs at those small scale level is quite recent and so the possibility of comparing present data with antecedent periods is limited, posing a great challenge for the development of the climate change assessment studies (Caurla et al., 2015).

3.1 INSIGHTS ON WINDSTORM EVENTS IN EUROPE: PAST TRENDS AND FUTURE EVOLUTION

Among the large number of extreme climatic phenomena that hit Europe, windstorms – especially the winter ones – have proven to be the most threatening and the most expensive natural hazards all over Europe, representing de facto one of the main leading sources of insured losses within the European area (Leckebush and Ulbrich, 2004).

Before going further, a premise defining what an extreme windstorm refers to, within the European context, is due. According to the European Environment Agency (EEA, Report No 15/2017, p.63), European windstorms are presented as "*atmospheric disturbances that are defined by strong sustained wind. They can range from relatively small and localised events to large features covering a substantial part of the continent. Large storms in Europe are extra-tropical cyclones; they develop from low-pressure weather systems that capture their energy from the temperature contrast between the sub-tropical and polar air masses that meet in the Atlantic Ocean.*"

The European society and the scientific community started gaining serious interest towards the study of such events only after the occurring of some exceptional and extreme windstorms in the 1990s, like Daria in January 1990 and Lothar in December 1999, each of whom caused around 100 fatalities and more than US$8 billion in inflation adjusted insured losses, comparable only to the typical hurricane events occurring in the US (Berz, 2005).

However, the 1990s represented the turning point for the study of storm dynamics in Europe, but despite the serious efforts some methodological problems have been undermining the scientific research and still remains today a big challenge.

A major constraint is that many variables which seem to be very suitable for research purposes are not completely reliable to trace common patterns as the databases are relatively young, or the given data sets suffer from inhomogeneities, meaning that the data are contaminated by other external factors, they are scattered in terms of scope and variable analysed and so as result they are hardly comparable, making difficult the identification of general patterns (Matulla et al., 2008).

To date, there are few reliable databases, and the most important for the study of windstorms include "The XWS open access catalogue of extreme European windstorms from 1979 to 2012" (Roberts et al.,2014) and the "Spatially explicit database of wind disturbances in European forests over the period 2000-2018" (Forzieri et al., 2020).

Despite limitation and bottlenecks that have hinder data collection on European storms, recent researches were able to delineate some general traits.

It emerged that the majority of severe windstorms involving the European area is represented by extra-tropical cyclones that occur mainly between October and March (Leckebush and Ulbrich, 2004).
By tracking those storms' paths, evidence has shown that extreme windstorms are generally affecting countries in the north of Europe, especially Iceland, Scandinavia, Ireland and the United Kingdom (Hoskins & Hodges 2002).
Occasionally windstorms can develop and move further southwards, for example when the jet stream is in a more southerly position, and consequently, also southern Europe countries like France, Spain or Italy can be affected by those extreme events (Hoskins & Hodges 2002).
The case of the windstorm Vaia stands as proof of such perilous unprecedent exception for Italy's usual climate events, representing an important wake-up call for windstorm studies and emergency climate management (Regione Veneto, 2021), especially in view of the extensive damage reported to forests and communities within the affected area, duly mapped through a multi-means approach e.g. satellite photography study, as presented by Chierici and colleagues in 2019 (Chierici et al., 2019).
It has been then supposed that the alleged climate change and the increasing global mean temperature induced by the human-made greenhouse gas emissions would cause a change in the geographical trends concerning the occurrence of climate extremes, especially in those areas traditionally not accustomed to cope with those phenomena (IPCC Report, 2012.).
Applied to windstorms, these conditions could slowly lead towards a future scenario where the increasing frequency in the occurrence of extreme windstorms would start hitting regularly also less common areas, as evidence has shown with the example of central and southern Europe (Leckebush and Ulbrich, 2004).
In view of the likelihood that such windstorms could move more frequently towards unusual areas, it is important to consider that, as consequence, the extended coastal and forest zones will be particularly exposed to the risk of unprecedent heavy damages. Thus, to prevent damages and design adequate mitigation strategies it is impellent need to set up a better storm forecasting and storm tracking system in order to identify the most vulnerable areas (Leckebush and Ulbrich, 2004).
For what concerns the detection of the physical features of European windstorms, several studies have been conducted in order to find out variables and indices useful to individuate and define the characteristics of an extreme windstorm (Leckebush and Ulbrich, 2004; Roberts et al., 2014).
Wind speed has been identified as one of the main indicators of a storm's magnitude.

It has been established that a threshold of 25 m/s represents the wind speed at which damages starts to occur: within 19,5 and 22,6 m/s only cause damages to branches of trees and chimney pots, while when the wind blows within 23,1 and 26,8 m/s it starts uprooting trees and severely damaging buildings (Roberts et al.,2014). By taking this variable as reference it can be identified the severity of potential damages.

Depending on the severity, windstorms could have strong repercussions to society wellbeing, causing important structural damages, cutting the power to millions people or shutting down entire areas from the transport networks.

In function of the variables and the parameters considered there are several ways to assess in which measure a windstorm could be defined "extreme": for example, the severity of a windstorm can be assessed by analysing its physical parameters, such as the wind speed and the geographical extension, identifying the impacts on ecosystem damages or measuring impacts on socio-economic variables determining the total insured losses or the human mortality caused (Roberts et al.,2014).

Fig.6 shows a list of the 23 most destructive European storms collected within the Extreme Windstorms Catalogue (XWS) for the period between 1987 and 2012.

In the table the main characteristics of these events are shown in the detail, such as their maximum peak of wind speed (*Umax*), the date in which the maximum peak of wind speed occurred, their geographical extension and also the total value of the insured losses in the post-storm scenario. What appears is an evident increase of extreme windstorm events within the period of the 1990s, followed by a more homogeneous distribution of such events from the period from 2000 up to 2012. Unfortunately, the observational period remains too limited for an effective forecasting of future trends of windstorms in Europe, letting once again the uncertainty of such phenomena showing up its challenging nature.

Then, such unpredictability represents a significant risk especially for the forestry dimension, which is recognised as one of the most exposed sectors to the effects of windstorms (EEA, 2017). According to studies, an increasing occurrence of windstorms is likely to diminish the primary output of forests, partially balance carbon sinks, or potentially convert such fragile ecosystems into carbon sources (Forzieri et al., 2020).

So, within this context of general incertitude, it is even more urgent starting to understand the extent to which storm activity in Europe is influenced by climate change, and which will be the consequences in the future scenario: under the methodological viewpoint this research can be addressed through the observation of satellite data and coupled with the integrated analysis of simulated cyclone activity by using statistical tools and models like the general circulation models (GCMs) (Leckebush and Ulbrich, 2004).

Name	Date of U_{max}	U_{max} ($m\,s^{-1}$)	N (25 km grid boxes)	S_{ft} ($m\,s^{-1}$)	S_f ($m\,s^{-1}$)	S_{f98} ($m\,s^{-1}$)	Insured loss (USD)
87J	16 Oct 1987	39.53	622	38 424 457	65 338	104.56	6.3 bn
Anatol	3 Dec 1999	39.86	742	47 007 178	48 102	94.62	2.6 bn
Dagmar-Patrick	26 Dec 2011	30.08	65	1 769 600	516	39.43	0.04 bn
Daria	25 Jan 1990	37.92	881	48 047 669	53 068	72.57	8.2 bn
Emma	29 Feb 2008	25.12	768	12 169 633	7874	78.00	1.4 bn
Erwin	8 Jan 2005	39.22	598	36 077 572	40 914	79.23	2.2 bn
Fanny	4 Jan 1998	34.60	297	12 300 569	6296	15.80	–
Gero	11 Jan 2005	39.13	293	17 552 256	23 032	9.96	0.6 bn
Herta	3 Feb 1990	33.16	437	15 936 658	12 733	49.40	1.5 bn
Jeanette	27 Oct 2002	36.92	1497	75 367 239	91 060	219.21	–
Klaus	24 Jan 2009	37.23	472	24 356 496	26 469	140.22	3.5 bn
Kyrill	18 Jan 2007	36.38	1234	59 432 000	8756	164.46	6.7 bn
Lore	28 Jan 1994	31.60	438	13 818 494	4431	54.17	–
Lothar	26 Dec 1999	36.72	380	18 818 478	10 612	69.09	8.0 bn
Martin	27 Dec 1999	37.18	415	21 328 371	24 460	132.26	3.3 bn
Oratio	30 Oct 2000	38.45	645	36 667 755	18 846	56.39	–
Stephen	26 Dec 1998	39.53	317	19 575 792	36 071	10.16	–
Ulli	3 Jan 2012	36.32	397	19 019 179	15 988	14.19	0.2 bn
Vivian	26 Feb 1990	35.16	940	40 864 068	56 775	73.69	5.6 bn
Wiebke	28 Feb 1990	32.24	751	25 163 891	3382	118.11	1.4 bn
Xylia	28 Oct 1998	26.72	295	5 625 905	2680	54.07	–
Xynthia	27 Feb 2010	32.62	666	23 109 656	18 706	138.80	2.9 bn
Yuma	24 Dec 1997	39.92	205	13 039 350	4035	3.33	–

Figure 6. *The 23 most destructive windstorm events in Europe and their main characterizing features. Losses have been converted to be indexed to 2012 value. Source: Extreme Windstorms Catalogue (XWS)*

At general level the models' simulations are run according both to a scenario in which the anthropogenic component and climate change are not primarily considered and to another scenario in which such components are assumed as fundamentally relevant in order to establish possible tendencies (Roberts et al.,2014). What currently emerged from those two main branches of models' simulations could be generally summed up as follows:

a. within the first category of simulations, it is actually estimated a tendency in a decrease of the total number of winter cyclones; however, for some regions, e.g. the British Isles region, an increased number of intense cyclones is identified in GCM simulations. Furthermore, these changes in cyclone activity appears also to be generally connected with an increase in wind extremes over Western and Central Europe (Pinto et al.,2012)
b. within the second category analysed, scenarios based on a chain of assumed emissions, global and regional climate models point to a slightly more violent future of European storminess, storm surges and waves in the North Sea; moreover, for the end of the century an intensification of up to 10% is envisaged, mostly independently from the emission scenario used (Roberts et al.,2014).

Another important aspect to consider when analysing possible future scenarios is how changes in storminess will impact socio-economic dimensions. An economic sector particularly sensitive to wind related damages is the insurance industry. The total reported economic losses caused by weather and climate-related extremes in the 33 EEA member countries over the 1980–2016 period amounted to EUR 450 billion, and the second main damaging factors were storms causing 25 % of total insured losses (EEA, 2017).

The emerging picture is that nowadays, there are no populated areas in the world totally safe from being affected by such extreme events. While some societies have already learnt to live with windstorms and are prepared for mitigating their impacts, others are actually lacking the operational and structural tools for dealing with such violent storminess (EEA, 2017).

3.2 INSTITUTIONAL APPROACHES WITHIN THE MANAGEMENT OF WINDSTORM HAZARDS

As previously introduced, vulnerability to storms depends on a multiplicity of variables, both environmental and socio-economic. Thus, it is important to have a comprehensive understanding of the effects storms can have and then identify strengths and weaknesses of each of the abovementioned dimensions.

Along the scientific evidences drawing attention towards this impelling challenges, institutional responses are needed as well in order to provide for reliable and effective measures.

Indeed, if the character and severity of impacts from windstorms represents a physiological and unchangeable feature, it is also true that other important aspects like exposure and vulnerability must be taken into account when looking for possible solutions.

As aforementioned, the range of vulnerability and exposure is very wide since is varying according to the different geographical areas considered and is determined by other numerous influencing factors including among others the natural climate variability, the anthropogenic component and the socioeconomic structural development of the area (Pinto et al.,2012).

The institutional responses to such climatic hazards during the last decade, have been designed in an increasingly conscious manner, paying a close attention especially towards the awareness raising within society and the enhanced value of institutional cooperation. (cit).

The founding pillars of such supra-national policy framework dealing with the climatic challenges, was based on the collaboration between the different institutional and scientific actors , as for example the UN, EU and IPCC, that are posing the bases for very important strategies, namely the disaster risk reduction (DRR), disaster risk management (DRM) and on adaptation and mitigation policies (IPCC,2012).

But more specifically, what does it mean “disaster risk” within this context?

According to the IPCC special report on extreme events and disaster risk management published in 2012, this particular concept is defined as *"the potential loss of life, injury, or destroyed or damaged assets to a system, society or community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity*"(IPCC Report, 2012, p.3)

Within this broad definition of risk are included key terms for identifying risk strategies like e *acceptable risk* and the *residual risk*. The former term represents the extent to which a potential risk is considered acceptable or tolerable, and it is depending on the existing social, economic, political, cultural, technical and environmental conditions, while the latter indicates the disaster risk which remains even when effective measures are set in place, and for which emergency responses and recovery capacities are still needed (IPCC, 2012).

The presence of residual risk implies a constant attention towards the development and support of effective capacities for emergency services, preparedness, response and recovery plans, together with socio-economic policies such as the creation of safety nets and the implementation of risk-transfer mechanisms (EEA, 2012).

Therefore, considering more into the detail the institutional approaches within the topic of disaster risk, it can be assessed that the disaster risk management (DRM) represents the empirical application of disaster risk reduction (DRR) strategies aimed at preventing possible new disasters while reducing existing risks (IPCC, 2012).

In order to have a clearer idea on how the impacts of disasters are tightly intertwined to vulnerability, exposure and climatic events, *fig.7* offers a schematic overview showing the influence of natural climate variability and anthropogenic climate change on extreme events. Secondly it identifies an assessment of the exposure and vulnerability of human society and natural ecosystems towards disaster risk.

It is enlightened the key-role of development as core strategical element for the reduction of exposure and vulnerability to disaster risk. Indeed disaster risk management and adaptation strategies are useful to reduce socioeconomic and environmental exposure and vulnerability (IPCC, 2012). Moreover, it is also important to note the fundamental role that DRM, coupled with adaptation strategies *(fig. 7)*, plays within the framework of risk-reduction policies: they are both focused on diminishing exposure and vulnerability and increasing socioeconomic resilience to the potential adverse impacts of climate extremes, allowing an improvement within the capacity of societies and communities to prepare for and respond to future disasters, even though risks cannot fully be eliminated.

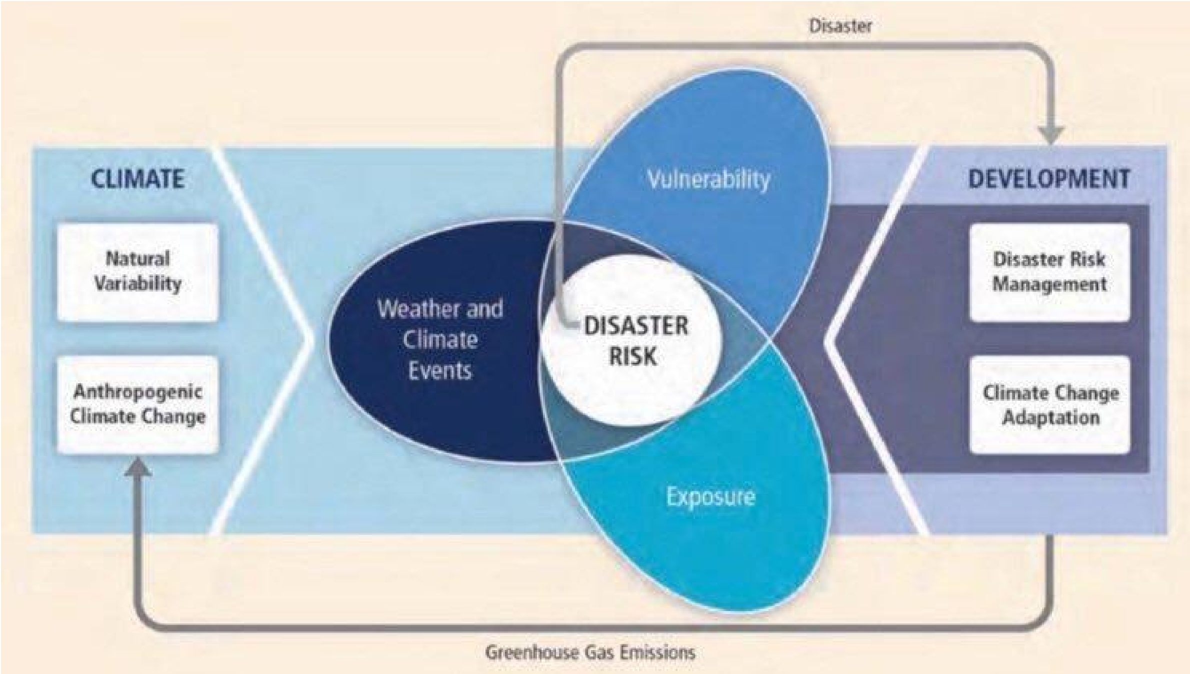


Figure 7. *Core concepts of the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). Source: IPCC Report, 2012*

Summing up, it can be said that DRM and DRR are interconnected concepts: indeed, DRR represents the policy objective of DRM, since the aims of the latter are defined in DRR action plans and strategies.

Within this framework, the so called *adaptive management* assumes particular relevance, especially when dealing with DRM policies: according to Pahl-Wostl (2009), adaptive management correspond to a *"structured process for improving management policies and practices by systemic learning from the outcomes of implemented strategies, and by taking into account changes in external factors in a proactive manner"*.

This approach is characterized by a strong interdisciplinary nature, aiming at bringing together scientific findings, experience and traditional knowledge with the final objective of empowering decision-making and policy-making through a "learning by doing" rationale. Through an adaptive management of DRM, decision makers are encouraged to be flexible in their approach, adapting their decision to new information available and territorial and societal transformations (Pahl-Wost, 2009). Indeed, emphasis is put on the importance of a more rapid and flexible knowledge-acquisition and the need of improving the information flows between policymakers and all the other interacting actors (eg. civil society, civil protection, NGOs).

Assumed therefore the importance of the synergy between DRM approaches and adaptation policies, the main overarching targets emerging within the supra-national policies responding to the need of coping with extreme climatic events and their related risks that have been analysed above, can be concisely summarized as follows:

a. reducing exposure and vulnerability to ECEs;
b. increasing the socioeconomic resilience to changing risks;
c. transferring and sharing risks (eg. insurance and financial tools);
d. preparing, respond and recover.

Then, it is important to remark how the significance of such key themes has been largely featured also within the international climate summits, having as overarching goal the development of a commonly shared methodological framework in order to support national governments in developing more effective DRM and adaptation strategies, jointly with DRR and communities' resilience (EC, 2013).

An increasing focus has been put on the need of a more effective integration of disaster risk strategies into common development policies, planning and programming at all levels, with a special emphasis on disaster prevention, mitigation, preparedness and vulnerability reduction, stressing also the improvement and strengthening of institutions, social mechanisms and capacity building at all levels, in particular at the community level, which could systematically contribute in enforcing resilience to face the increasing threats posed by climatic hazards (UN, 2005).

Thus, tackling disaster risks from the occurrence of ECEs, requires as well a more performing methodological framework in order to reduce the exposure and vulnerability to them: a disaster management policy needs to encompass prevention, resilience and reduction of individual vulnerability and strengthening ecosystems, not only through the political and institutional resources, but also by trying to rely on a multidisciplinary approach, involving and including other helpful tools, such as for example urban and land-use planning (EC, 2013).

The approaches discussed above represents mainly the general theoretical guidelines within the management of climatic hazards, especially in light of the wide range of reported ECEs and consequently, this general framework presented will have then to be adapted according to the specific kind of hazard taken into account.

3.3 THEORETICAL APPROACHES FOR THE IMPROVEMENT OF DRM

As seen up to that point, disaster risk management of windstorm damages has proven to be a highly complex and unpredictable process especially in light of the wide range of possible risks and all the interconnected actors involved within such process, each of whom is bringing in its specific goals, beliefs and ambitions.

This multiplicity of actors' interests revealed the need of providing more suitable theoretical frameworks for supporting effectively DRM strategies. Despite theoretically has been highlighted the need of multidisciplinarity and interconnection among different strategic areas, usually crisis management strategies are carried out in a fragmented manner, leading as consequence to a dispersion of financial resources which then could seriously undermine the results of the decision-making processes (Riguelle et al., 2016).

These circumstances are largely due to the fact that DRM strategies for tackling widening issues such as risks of severe windstorm damages over Europe, are a relatively "young" research field and so as result this knowledge gap is reflected even at the practical level as a lack of coordination among stakeholders and weak responses from the public authorities.

A better coordination among stakeholders and institutional bodies should be the first fundamental requisite to be pursued in order to deal successfully within the management of windstorm damages. If on one side public authorities hold the strategic and legislative levers to set in place effective DRM strategies, on the other side they are lacking adequate supporting tools and local information, which in contrast are the specificities characterizing stakeholders, and jointed with their innovation capacity and local expertise of context and its related problems and needs. Including stakeholders in the decision-making procedure could bring a positive and valuable impact in filling the existing gaps among public risk governance and the related public policies (Riguelle et al., 2016), making the strategic responses to potential windstorm damages more effective and better tailored according to the local challenges envisaged.

The first interesting approach which could significantly improve DRM strategies is the integrated management of risks.

Since the management of windstorm damages is characterized by a high level of structural complexity, this strategy aims at turning the making of the decisional process from an individualistic approach to an integrated one, ensuring collaboration among several actors (Riguelle et al., 2016).

As presented by Riguelle and colleagues in 2016, the main goal of such integrated approach is to understand and combine interests, expectations and beliefs from all stakeholders.

The overarching idea of this approach implies that institutional and non-institutional actors should be capable to handle in a shared manner the large variety of risks that socio-economic structures are facing within the occurrence of windstorms in a way that the effects and impacts of such threats are reduced.

Fig.8 shows the generic framework for the implementation of the integrated approach applied to the forestry sector (Riguelle et al.,2016). It emerges the multi-layered structure involving the different levels of integrated analysis and how the multitude of stakeholders' goals is translated into a risk management strategy, taking into account risks in their full dimension and all the possible scenarios and consequences deriving from the elements of uncertainty.

Summing up, it can be said that within this approach, the aspect of mutual collaboration is particularly highlighted in order to make sure that all perspectives in the risk analysis are integrated within the decisional process and moreover, coupled with the sharing of strategic information.
In order to cope effectively with such level of complexity, further supporting methodologies are needed and so the systemic approach represents the last analytical framework taken into consideration, dealing with the study of decisional processes and the related contexts at their aggregated level.

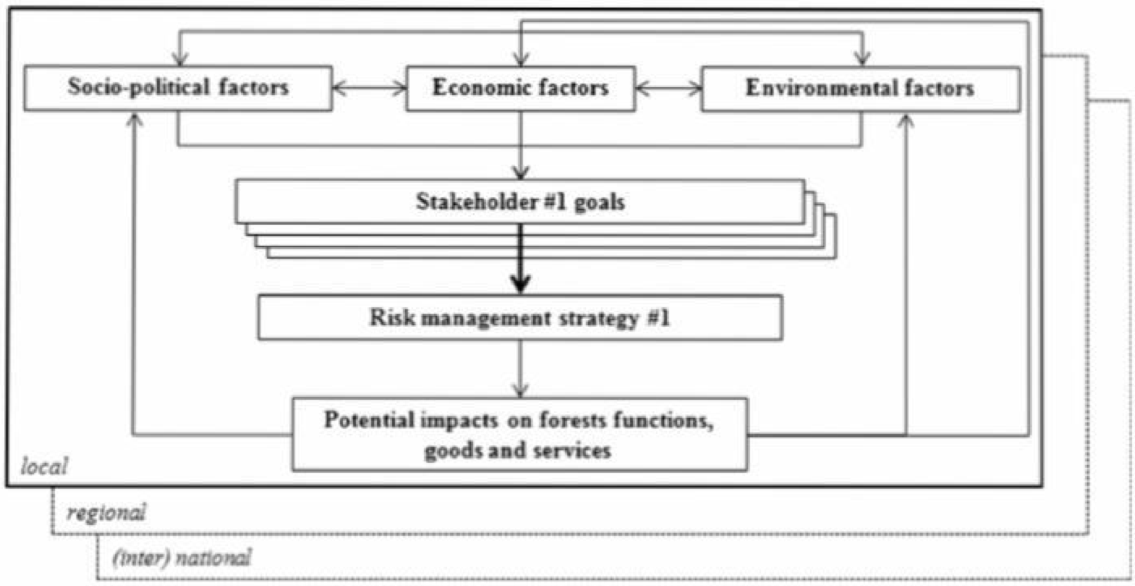


Figure 8. *Generic framework for the implementation of integrated approach. Source: Riguelle et al.,2016*

Also known as *systems thinking*, this framework is used for analysing the multiple dynamics of a system through simulations, which then allow the identification, optimization and the classification of the studied system as well as a parallel analysis concerning system's resources and constraints (Riguelle et al.,2016).
Such approach is particularly useful for the setting up of different windstorm damages scenarios, because thanks to the determination of the system' scale, boundaries, inputs and outputs jointly with its associated risks, costs and benefits, risk mitigation strategies at the systemic level can be carried out.
The following *fig.9* shows a schematic overview of the main strategical actions which should be set in place within a systemic risk mitigation plan, in order to improve the context's resistance and resilience, having again as reference the forestry sector.
By using systems thinking modelling approach, all the major elements of fragility are individuated and consequently, there can be found strategies addressing or preventing those

weaknesses before another crisis follows, allowing an improvement among the system's resistance and resilience.

Overall, it can be said that both resistance and resilience strategies of action are calling for an enhancing of the information and preparedness level, as well as a strengthening addressing the management of the economic context by making more accessible the macro-economic information of the involved system which are essentials in quickening and coordinating the operational responses towards the management of windstorms effects and potential impacts.

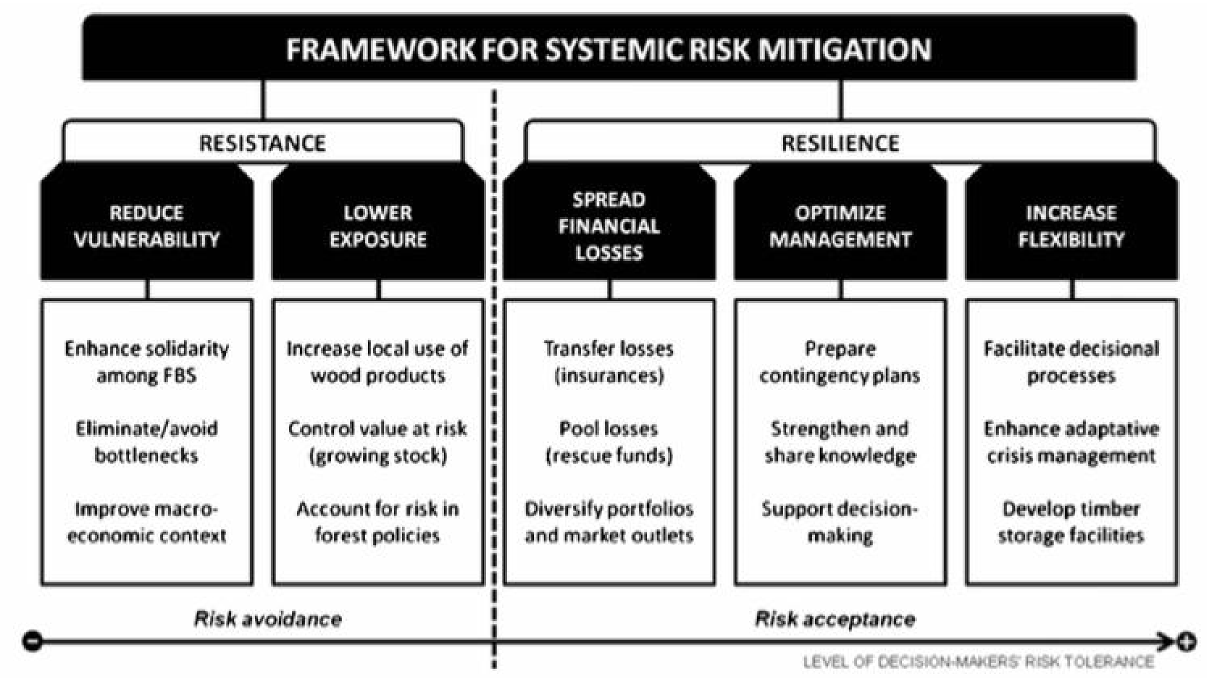


Figure 9. *Strategies for mitigating the impact of windstorms at the systemic level. Source: Riguelle et al., 2016*

3.4 ECONOMIC IMPLICATIONS ON WINDSTORMS' OCCURRENCE

In light of the economic effects that windstorms are having across Europe further considerations have to be added to the policy framework just presented. Indeed, the occurrence of ECEs cause economic disasters that can be counted in billions of euros every year, affecting the economic stability and growth of the hit areas and sometimes, also having bigger repercussions. In fact, such climatic hazards may also have cross-border effects and can potentially involve entire areas in neighbouring countries too.

Then, even in those cases where costs of major damages are locally concentrated, if such costs are poorly covered by the insurance system, the individual Member State may carry heavy fiscal burdens and so as consequence, that could cause internal and external imbalances to the MS economies, representing an important obstacle also for all citizens, companies and governments across the European Union (EC, 2013).

The following *fig.10* shows an indicative example of the maximum historical losses caused by winter and wind storms across Europe in 2010, reminder of the fact that windstorm hazards does not strike evenly and so a common system to manage the risk of economic losses is needed in order to overcome the resulting economic imbalances: it is sufficient to note that between 1980 and 2011, the economic toll of natural disasters in the whole Europe nearly approached 445 billion of euros - in 2011 monetary values - and about the half of the total losses has been attributed to a few but highly destructive windstorms, namely Lothar in 1999, Kyrill in 2007 and Xynthia in 2010 (EC, 2013).

Figure 10. *Natural Catastrophes: Risk relevance and Insurance Coverage in the EU. Source:Joint Research Centre, European Commission (2012)*

Moreover, considering that the potential damages from ECEs cannot be geographically ascribable to one defined area, the attentions towards the financial aspects of disaster risk management and the economic costs of ECEs disasters have found large space within the debate among the institutional spheres, both at the international level – since Yokohama in 1994 and then within the Hyogo framework in 2005 – and within European institutions, for example when the European Council released in 2013 a consultative document, the Green Paper, addressing the attention on the need of a common methodological framework to facilitate an adequate budget coverage of disaster risk insurances and financial risk transfer markets, calling as well for a regional insurance pooling, in terms of knowledge transfer and reinforced cooperation between MS (EC, 2013).

Since it has been acknowledged that windstorm damages tend to be both prevention and preparedness sensitive and impacts, as well as response needs, can be mitigated via proper preventive and preparedness measures (Roberts et al,2014), improving the implementation of

DRM strategies could surely help in promoting a more effective economic development with less complications over the time, especially on the long period.
It is already known that major natural disasters have large and significant negative effects on economic growth and economic activities, both in their intermediate impact and in the longer term: specifically, it is mainly the uninsured losses that drive the subsequent macroeconomic costs and imbalances and within the climate change framework discussed above, it has been estimated that the insurance system will be progressively overstressed in covering the effects of such increasingly frequent and severe ECEs (EC, 2013).
In fact, such changes in climate, jointly with other big challenges like demographic growth, population concentrations in catastrophe-exposed areas and the uneven rising of wealth are consequently making more and more difficult dealing with the exposure and vulnerability of the socioeconomic structures and the severity of potential economic losses within the post-ECE scenario, especially considering that overall, the probability of most types of significantly extreme weather events is expected to grow over time (Leckebush and Ulbrich, 2004).
In regard of such complex dynamics, the insurance system has been indicated as a particularly suitable tool within the DRM strategies: while in the short term the effects of climate change and the related extreme climatic events may not be that felt within the insurance system, on the contrary in the long term, especially in those sectors where insurance is not customary, climate change could have an impact on the availability and costs of insurances, which might then become unavailable or unaffordable in certain areas, especially in light of the increasing risks.
And the unavailability of insurance, represents an important factor contributing to the increasing of societal vulnerability and exposure, leaving governments as well with potentially large financial exposures which may lead to severe economic shock (EC, 2013).
Then, the reason why the insurance system has been identified as a valuable support within DRM strategies is because it is a tool that goes together with risk prevention, risk preparedness and response measures in dealing with ECEs: indeed, a properly functioning disaster risk insurance system, beyond risk sharing, could be operational at all levels of the risk management cycle, from risk identification and risk modelling to risk transfer and recovery (EC, 2013).
Within this complex and interconnected dynamics, the insurance system covers a pretty specific role: despite it cannot prevent the loss of lives or assets, evidence has shown that it could help in diminishing the economic pressures after disasters, while facilitating the recovery.
In fact, it has been assessed that a well-tailored insurance system is capable of effectively redistributing and reducing the financial risks associated with adverse climatic events, by sharing costs either between individuals or over time (EC, 2013), relieving the pressure from the hit national economic system.

But how could it be managed at the practical level? According to the Green Paper released by the European Council in 2013, it has been assessed that the insurance system within the DRM should transfer individual risks to a pool and then, by aggregating or pooling the several potential risks – for example including flood, fire and storm risk within the basic insurance of private houses or company buildings– it would be finally possible to reduce the cost of climatic disasters in any particular time period and relieving the pressure on the MS' emergency funds. And in light of such reasons, it has been encouraged the adoption of compulsory disaster insurances, possibly including a wide range of ECEs, in order to make them more covering: usually, bundling together several types of mostly uncorrelated climatic hazards into a single insurance policy – for example fire, flood, or storm risk as aforementioned – allows a reduction within the potential risks of any one perils included in the insurance policy and in addition, product bundling also represents a general guarantee of solidarity towards consumers.

Therefore, product bundling within the insurance system is sometimes introduced through a mandatory extension of simple risks such as fire or motor insurance to natural disasters coverage (EC, 2013).

Indeed, well- designed insurance policies could have a higher market penetration, resulting in a larger pool of insured people and companies, reducing also the administrative costs per policy in the long run and diminishing the possibilities of economic imbalances and fiscal burdens even in the most severe cases of ECEs.

Summing up, the overarching idea of the above presented financial tool suggests that in general, both business owners and citizens should not just rely passively on national emergency funding measures, because their dependency on state aid in case of any severe ECEs' occurring could lead to damaging individualistic behaviours and slowing down the recovery effort from the climatic disaster: instead, there should be a multilateral work of awareness raising aimed at creating consciousness around the fact that subscribing an insurance would mean having more protection in terms of coverage from damages and in terms of risk sharing and risk transfer as well, allowing the institutional decision-makers to act more effectively thanks to the integration of such tool within the operational process of recovering.

4. REVIEWING FOUR CASES OF EUROPEAN EXTREME WINDSTORMS

4.1 CASE STUDY 1: WINDSTORM LOTHAR

4.1.1 SOCIAL ASPECTS OF WINDSTORM LOTHAR

Storm Lothar, which hit northern and central Europe in December 1999, was classified as one of the most powerful European windstorms of the last century (Hartebrodt, 2004). The windstorm affected several countries, especially Germany and Switzerland.

For what concerns the German case, the windstorm Lothar has particularly damaged the region of Baden-Württemberg, the third largest of the 16 German landers. In this area internationally renowned for the Black Forest, forest spaces accounts for 39% of the territory.

Within this region there are three types of forest ownership: the federal state which owns the 24%, private forest owners owning the 38% and communities, which manage the 37% (Hartebrodt, 2004). Within this analysis, the type of forest enterprises known as Farm Forest Enterprises (FFEs), belonging to the 2nd aforementioned category, are the focus of the study as historically they have played a key role within regional forest management and furthermore they represent a vital source of income for private owners and local communities within the lander. Another reason why FFEs represent the focus of the following analysis is that storm Lothar heavily affected the part of the region where this type of enterprises are concentrated (55%), creating serious medium and long-term damage to over 40% of local FFEs (Hartebrodt, 2004), making it an interesting ground for the study of disaster risk management and approaches that have been set in place.

The economic gain of the 260.0000 FFEs active over the territory comes mainly from three sources: tourism, agriculture and forestry activities. It is estimated that the productivity of forestry activity within the system of FFEs, in respect of labour efficiency in terms of income return per hour is much higher than any income earning deriving from the other activities (Hartebrodt, 2004). It is immediately evident that the forestry dimension plays an essential role as stabilising element for the communities' economic management of the territory (Hartebrodt, 2004). Thus, storm Lothar posed a significant threat to the area's socioeconomic viability.

When storm Lothar hit the region, it destroyed approximately 5.2 M m^3 of timber belonging to private forest owners from FFEs. They constituted the group who suffered the most serious losses since the wind-thrown timber was almost four times their prescribed annual cut (Hartebrodt, 2004). Of course, a damage of such magnitude couldn't be overcome in a short time, so which are the strategies set in place by the different actors to cope with such dramatic consequences?

For what concerns the FFEs community, three main elements have proven to be fundamental within the successful management of the post-storm economic and environmental recovery, namely the FFEs proactive approach, the investment policy chosen and the state-run support.
As the windstorm hit, FFEs immediately took a strategic decision that resulted in huge savings in external costs, thus minimising the long-term repercussions of the damage suffered. Specifically, it is well known that in the post-storm scenario, the damaged timber has to be processed in a short time period to avoid deterioration and pest risk (Hartebrodt, 2004): consequently, there is an increase in expenditure for clearing, processing and transport wind-thrown timber that would normally require a large external expenditure (eg. hiring extra workers, clearing and processing equipment, external consultancy…). Despite it was evident that for FFEs was unavoidable to integrate more external inputs for the management of the operations, they were able to make strenuous efforts to keep such external expenses to the essential minimum. How? The Baden-Württemberg system of FFEs took the strategic decision to rely significantly on the self-processing of damaged forests by actively involving family members and neighbours, by increasing the labour input man-hours\ha spent in their own woodlots reducing in this way expenditures for external workers or forest service enterprises. Comparing the years 1999 and 2000, the increase of worked hours per hectare amounted to more than 85% within the second year (Hartebrodt, 2004), and it has been estimated that a difference of about 30 M Euro was retained by the farm families by applying such strategy (Hartebrodt, 2004).
As the following *fig.11* illustrates, within the year following the storm, while the other two types of forest ownership had a self-processing rate of 35% as they were forced to rely on huge external inputs, FFEs owners had instead a self-processing rate of more than 70% (Hartebrodt, 2004).
To maintain high rates of self-processing, the FFEs' owners decided then to increase their investment activity by purchasing a lot of forestry equipment (e.g. ground cables and winches) in order to maintain autonomy in the logging and timber processing, always following an economic logic of minimizing external sources of expenditure (Hartebrodt, 2004).
Regardless the efficiency demonstrated by FFEs and the investment policies implemented, it must be said that companies with wind-damaged timber amounting to more than 100% of their annual cut were losing an important part of their economic base (Brandl, 2011). In fact, it has been estimated that FFEs with storm-damaged timber exceeding five times their annual cut were about to face a 60% drop in their income (Hartebrodt, 2004).

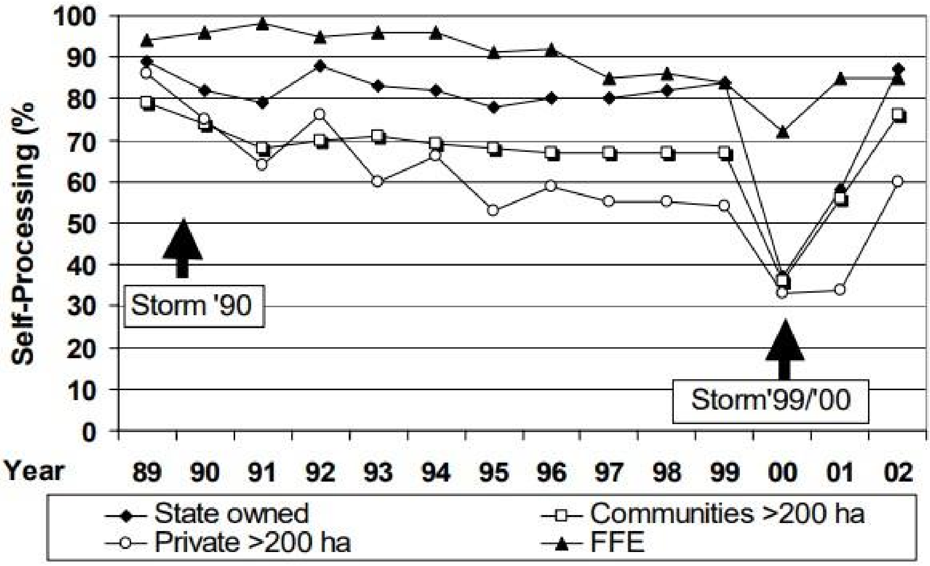


Figure 11. *Data displayed show the rate of timber processed by own workers or family members respectively in 1990 after storm Vivian, and in 1999-2000 after the windstorm Lothar. Source: Hartebrodt et al., 2004.*

In this context, the third element of this case proved its importance: without state support, FFEs would necessarily have had to switch to other economic activities.

How was state-run support organised in the post-windstorm scenario? Two tools proved to be particularly effective in managing and reducing Lothar's damage. The first instrument has been the farm forestry accountancy network, created in 1972 by the Department of Economics at the Forest Research Institute of Baden-Württemberg with the aim of identifying the socio-economic dynamics of this type of forest owners, and keeping track of the economic data of companies in the area. Such database provides valuable information concerning all the relevant aspects of the FFE enterprise, enabling a detailed description of the economic impacts and allowing the development of accurate economic trends (Brandl, 2011).

The second useful tool for storm damage management was the delivery of an opinion poll conducted among a representative sample of owners from FFEs. Through face-to-face interviews, it was possible detecting the emerging needs in the first instance and then to assess the degree of satisfaction with the government measures implemented. The synergic combination of these two tools allowed the government to create packages of subsidies and assistance in line with the needs found among the FFEs community and calculated thanks to the forecasts made possible by the data of the farm forestry accountancy network (Hartebrodt, 2004). Specifically, to support the FFEs system the lander has put in place assistance measures in three areas, namely tax policy, allowances and joint sale (Hartebrodt, 2004).

The income tax on FFEs owners has been partly or totally remitted, according to the intensity of damage and three different kind of subsidy programs have been offered as well as marketing consultancies and information services from forest officers and experts (Hartebrodt, 2004).
Specifically, the ministry of Food Agriculture and Rural Development offered subsidies of fixed amounts in the case where the costs could be defined with sufficient prevision with the support of the accountancy network data, financed operations with a percentage of the costs incurred and facilitated the heavily affected enterprises with special loan programmes of medium term (3-4 years on average) at reduced interest rates (Hartebrodt, 2004).
Among the joint sale and information services, various forms of assistance have been offered to private owners: meetings and personal contacts with private forest owners have been carried out to advise them in all areas of interest (eg. log-processing strategies and marketing strategies) and such interventions have proven to be particularly helpful and successful since according to the opinion poll results there has been almost complete acceptance of the state marketing solution offered to sell the wind-thrown timber (Hartebrodt, 2004).
Furthermore, the region has also given priority to private forest owners for selling the damaged wood stocks, and this strategy has proven to be successful since in about one year after Lothar, the 93% of the storm-felled timber out of private forests has been sold (Hartebrodt, 2004).
The general conclusion is that the FFEs owners were able to influence their income over a wide range by choosing an efficient local-based approach, shedding light on the significance of family work and neighbourhood. Indeed, such strategic decision of FFEs resulted in a clear difference in their performance compared to the one of the other types of forest ownership present in the region. But since this major storm had as its most serious consequence the reduction of the natural asset base which caused several years of reduced supply, state-run subsidies on medium and long term coupled with the assistance network developed have proven to be fundamental in the design of a strategy for the development of resilience in the FFEs community and other forest actors of the German black forest (Hartebrodt, 2004).

4.1.2 INSTITUTIONAL AND ECONOMIC ASPECTS OF WINDSTORM LOTHAR

When storm Lothar hit also Switzerland on 26 December 1999, the consequences were particularly disastrous: 12 million m^3 of timber were damaged, not to mention the serious effects on buildings and infrastructure, the costs of which amounted to a total of 1.7 billion CHF (Brundl and Rickli, 2002). The following research provides feedback concerning the phases of the management set in place for dealing with windstorm hazards, namely the prevention, intervention and recovery, with a focus on the institutional tools employed.

As far as the prevention phase is concerned, the main operational reference should have been the meteorological warning system operated by MeteoSwiss (Brundl and Rickli, 2002).
Unfortunately, within Lothar's case, making an accurate forecast has been extremely difficult since even the large forecast models of international weather initially misinterpreted it as a little disturbance above the Atlantic Ocean (Brundl and Rickli, 2002). As consequence, its power and extent was only revealed the early morning of its coming, which resulted in shorter warning times that coupled with the holiday circumstances, led to a failure in disseminating the warning of the imminent hazard (Brundl and Rickli, 2002).
Such condition has consequently led to a very short intervention timeslot since the devastating event crossed Switzerland in just 2.5 hours, and so most of the responsible authorities were completely caught unprepared by the event (Brundl and Rickli, 2002).
The most affected areas were the Swiss plateau and the pre-Alps, as well as parts of central Switzerland: the passage of Lothar caused extensive damage not only to forests but also to buildings and national infrastructures such as transport facilities, telecommunication services and other kind of structures like cable cars and ski lifts leading the total quantifiable damage to approximately 1700 M CHF (Brundl and Rickli, 2002).
For what concerns forests, the total damage was equal to three times the normal annual forest utilisation and approximately the 3% of the growing stock for all Switzerland (Brundl and Rickli, 2002). The canton of Nidwalden was hit the most severely, with a windthrown amount ten time superior the normal annual utilisation of timber. Overall, storm Lothar heavily affected a total of 46.000 ha of woods, namely the 4.6% of the Swiss forest area and approximately the 50% of such area was completely devastated (Brundl and Rickli, 2002), for an estimated total loss of 750 M CHF.
The fact that most of the damage caused by Lothar was outside of the alpine area, on one hand surely facilitated the clearing and processing phase, but on the other its power has badly damaged the anthropized context. Within all the country, damage to structures and buildings has been estimated at CHF 600 million, not to mention other serious disruptions that have slowed down first aid and recovery procedures such as blocked roads, more than 80 railway lines cut off, boats and aircrafts damages (Brundl and Rickli, 2002).
How has the Swiss federal government handled this complex situation?
Repair work and assistance services to communities involved started immediately, while the process of recovery concerning the forestry sector has been organised and implemented by relying on the "Decision aid manual" released by Buwal in 2000, drafted after the disastrous experience from another extreme windstorm, Vivian, which heavily affected Swiss in 1990.

The aim of such manual was to draw conclusions from the information already available and make use of the experience gained as quickly as possible, despite the short period of observation after Vivian. Such manual intended to help institutions and forestry professionals in reaching decisions as to whether fallen timber should be removed from a specific windthrow area or left, relying on the rationale of economic feasibility and human resources availability (Angst and Volz, 2002).

Specifically, the decision aid was developed to assist forest managers in the political and operational management of large-scale damage in mountain forests and consisted of three parts: a checklist for damage reporting (part A), a column for stating the arguments for leaving or harvesting the timber (part B), and a third part providing background information. The checklist represents the actual working instrument (Angst and Volz, 2002).

The national management team set up immediately after Lothar hit and determined that measures for the protection of people, key infrastructures and unaffected forests would be given priority (Brundl and Rickli, 2002). It has then announced the availability of the decision aid as a support tool for local decision-makers, giving guidance not only on the issue of whether timber should be harvested or not, but also on which cases needed supplementary measures to be taken. Individual cantons then introduced their forest services to it in different ways: some cantons gave it directly to the foresters, held courses to promote the application or produced brief instruction plans with the help of the decision aid (Brundl and Rickli, 2002). Overall, the availability of this tool proved its usefulness in helping to produce clear and transparent processes of decision-making, since it was also relevant in explaining the decisions made to the population. Furthermore, it was noted by the media that the management team's instructions and the decision aid tool helped to reassure the residents and to avoid major conflicts with the nature conservation organisations (Brundl and Rickli, 2002).

In the context of storm Lothar, this reference manual enabled the affected cantons to develop recovery and support measures focused on the specifics of their local territories. Starting from the surveys for damage estimation, each canton then formulated different types of economic subsidies - whose rates ranged from 0 to more than 90% according to the local damage estimation - and the elaboration of the most appropriate strategies for the management and storage of fallen timber, such as, for example, the wood storage under plastic film which was applied for the first time on a large scale in order to avoid further depreciation within the selling markets (Brundl and Rickli, 2002).

In general, from this case it can be concluded that the presence of a handbook based on the previous experience of the windstorm Vivian represented an example of good practice which should be useful to take into account as it is very important that in those cases, politicians and governments can deliver a rapid response according to clear criteria. And so, the availability of an operational tool based on experience would have surely a decisive impact on the ability of those affected to carry out the necessary work quickly and effectively (Brundl and Rickli, 2002).

4.2 CASE STUDY 2: WINDSTORM GUDRUN

4.2.1 SOCIAL ASPECTS OF WINDSTORM GUDRUN

The second case examined is concerning windstorm Gudrun, which in January 2005 heavily affected northern Europe, causing severe damage especially in Sweden. This event was in fact the most damaging weather event known occurred in the country (Johannisson and Olaison, 2007). In terms of timber and wood production, the Gudrun's heavy wind effects resulted in forest damage equivalent to nearly a full year's harvest (Johannisson and Olaison, 2007).

However, the devastation to the Swedish forest was limited to a small area of the country, namely the South. Despite the impact was large but controllable on a national level in Sweden, it was devastating on a local level: indeed, approximately 80% of the productive forest area in the impacted region was owned by small-scale private individual owners (Johannisson and Olaison, 2007).

And it is precisely this latter topic that is addressed by the two papers presented below: the first, an interview-research focused on the issue of emergency entrepreneurship in the aftermath of Gudrun, developed in rural and isolated areas of southern Sweden. The second, an analysis of the adaptation logics of forest owners in managing their work in Swedish areas prone to heavy windstorm occurrences.

In the aftermath of a heavy windstorm occurrence, rural areas and small communities represent a fragile component within the organisation of recovery and assistance operations. Very often, the infrastructures linking those areas to more urbanised ones are severely damaged, and therefore in the first moments after the disaster, the social capital embedded within the affected communities becomes a fundamental key-feature for coping with the restoration processes (Johannisson and Olaison, 2007).

In 2007, researchers Bengt Johannisson and Lena Olaison published a very interesting study on such topic entitled "The Moment of Truth: Reconstructing Entrepreneurship and Social Capital in the Eye of the Storm" in which they have studied how the effects of the hurricane Gudrun were dealt with by civic and formal, private as well as public, organizations.

In particular, several actors from the communities in the south of Sweden have talked about their own experiences on field, explaining how local networking and social capital were crucial in the process of first aid and reconstruction after the destruction left behind by the storm.

The qualitative study has been conducted in the form of direct interview, involving five different categories of local actors in order to provide a more detailed pattern of the communities' tools and strategies deployed, namely (Johannisson and Olaison, 2007):

1. a spokesman for a civic association representing a rural community;
2. Ljungby municipality;
3. Two local small businesses dealing with forestry machineries, Rottne Industries Ltd;
4. An external corporate structure, E-on, the major energy provider in Southern Sweden;
5. Two intermediary organizations, among which the local airport.

Given the same initial circumstances, although the group of actors interviewed was heterogeneous, all the spokesmen pointed to the same problem: despite the fact that southern Sweden is recognized as an area prone in dealing with very powerful windstorms, no one was materially prepared for the devastating consequences that Gudrun inflicted to the region.

In addition to the log-locked roads, first aid assistance was extremely difficult for days - if not weeks - due to the extensive damage reported by the telecommunications infrastructure and also, the continuous power failures delaying restoration works (Johannisson and Olaison, 2007). In such conditions of total or partial isolation, communication with local institutional bodies was basically impossible, so as it has been reported "*any established organization structure by definition appeared as obsolete*" (Johannisson and Olaison, 2007).

Therefore, it was commonly felt a need to break out of existing structures, and so as reported by the different interviewees, local spontaneous taskforces have been organized as to operate autonomously, yet interdependently: just to quote some examples from the interviews, there have been local farmers associations lending fuel tanks to the community, private local companies bringing heavy clearing machines to re-establish road communications or also, retired cooks making hot meals for the workers from the communities engaged in non-stop clearing operations. Such examples clearly depict the empirical value of communities' social capital and the crucial role of local networking: once the external shock was recognized, social capital served a variety of functions in spontaneous organizing, including as a catalyst, lubricant, and safety net for the local communities (Johannisson and Olaison, 2007).

Local commitment has been pointed out as an important source of social capital in such a situation, helping in recognizing and supporting the rapid implementation of trust networks when constant and fast decisions must be made and appropriate actions must be performed immediately (Johannisson and Olaison, 2007).

Indeed, it was evident to all residents in the rural areas of the region where Gudrun struck that something substantial had to be done in the immediate aftermaths: this pressing need quickly evolved into a demand for specific services so informal and local organizations grouped together and started acting outside of the formal institutions' typical routines, relying on the rationale of the so called by the authors “emergency entrepreneurship”.

According to the study, the first initiatives after Gudrun hit were spontaneous and quick to organize. Local residents were often literally working in the dark, from strenuously battling with fallen and broken trees to trying to cope with corporate and public decision-making institutions which were delaying procedural instructions for needed actions.

The days were passing by and isolated communities were running out of food supplies and fuel so there was no time to debate or reflect. At that point, as the interviewees indicated, a push-triggered collective social entrepreneurship arose, releasing the same kind of innovation as pull-triggered individual or team commercial entrepreneurship: communities acted on the basis of intuition, drawing on previous experiences to deal with new situations, and networking extensively on the basis of the need for immediate action in the face of non-negotiable conditions that put material conditions and existential values at stake (Johannisson and Olaison, 2007). Overall, these cases clearly pointed out that leadership in emergency entrepreneurship originates in taking charge of one's own as well as of other people's lives and although the initiatives enacted in the above-mentioned examples were local and fragmented, they offered feasible and appropriate guidance, as well as a valuable inter-community cooperation examples for the future (Johannisson and Olaison, 2007).

Indeed, as it emerged from the study, every type of actor involved within the reconstruction process after Gudrun has directly benefited from such experience at the community’s level, for example:

- after Gudrun hit their territory, Ljungby municipality decided to carry out rescue operations "until the last resident had electric power" and within the following month they held meetings wherever and whenever needed, jointly with civic initiatives working voluntarily to the recovery operations. The interviewed spokesman reported that after such experiences they got invitations to go to other municipalities to share their lessons with them;
- the local company Rottne Industry Ltd was using retailers before Gudrun in dealing with used machinery. During the reconstruction process they offered vehicles to the community and even opened a “storm emergency” shop for spare parts. They now took advantage of the established networks to gather and disseminate information, looking for subcontractors from Europe, and they also work as mediators for second-hand machinery and logging vehicles of other brands;
- around the 60s the corporate E.ON's created 'LRF-supportive groups', developed in collaboration with the Federation of Swedish Farmers in the rural areas, with the aim of

always being able to have qualified personnel available on-field, which have proven to be fundamental within the recovery of power infrastructures in the region. Therefore, Eon has recognized the importance of preserving such local small groups and also, it has realized the need for a dual structure, one for routine operations, one to be activated in case of emergencies, the former increasingly global, the latter to be reinforced locally.

In conclusion, such on-field research highlighted the importance of recombining existing competencies into multiple local solutions as emergency entrepreneurship and localized creative organizing have successfully proven in the aftermath of Gudrun.

Particularly, evidence has shown how spontaneously organized multi-skilled rural communities have been able to open to new cooperative working paths in a physical landscape that had completely changed after the disaster (Johannisson and Olaison, 2007).

The lessons taught also re-establish the value of collective social capital, which is defined by strong links that foster solidarity and prompt action when it is most required. And as shown within the Gudrun's case, it is a form of social capital that may be "put to work" right away in the face of crisis conditions that are both unpredictable and ambiguous (Johannisson and Olaison, 2007).

As the authors suggested throughout the study, bridging and bonding social capital embedded in local communities should be taken into account as an unvaluable resource, since as seen, when combined with the attitude of community' and emergency entrepreneurship it is well capable to generate durable changes within the local territory Johannisson and Olaison, 2007).

4.2.2 SOCIOECONOMIC ASPECTS OF WINDSTORM GUDRUN

This second paper concerning Gudrun's effects in Sweden examines alternative approaches to the "business as usual" forest management model emerged from a qualitative study based on open-topic interviews of 51 individual forest owners from two rural municipalities in southern and northern Sweden, namely Vilhelmina and Lund (Andersson et al., 2018).

Among the group of interviewees, 40 of them spontaneously reported extremely valuable insights concerning the effects of storm and wind throw events on their present and future forestry businesses. Indeed, as previously seen, windstorm Gudrun had extensive social and economic implications over private forest owners, since they are owning and managing the majority of the affected areas (Andersson et al., 2018).

Although Gudrun has been the most devastating climatic event the country has ever experienced, it is generally agreed that with climate change windstorm disturbances in the country are more frequent and intense so as consequence, challenges for the forestry sector are increasing and the dominant market-based forestry model is not anymore a sustainable approach (Johannisson and Olaison, 2007).

Particularly, the main concern shared by forest owners is that such dominant forest management model considering only the economic profit may dangerously limit the chances for individual shifts of tendency towards more adaptive management approach of Swedish forests.

The Swedish forestry model has been unanimously described as a deregulated context in which forest governance is completely lacking active management of risks, since it is strongly oriented towards the maximisation of production and the supply of material only for a specific set of industrial products, without questioning the durability of such approach (Andersson et al., 2018). One of the major issues reported by the interviewees, especially in the post-Gudrun emergency situation, was the almost total disregard of forestry authorities for small-scale forest plots. The windstorm damage was so extensive that forestry professionals in almost all cases decided to focus their attention on much larger and more intensive plots, adding to the distress of the local economy a sense of lack of trust in the authority. And such profit-oriented approach has been perfectly highlighted in the aftermath of Gudrun: indeed, the presence of spruce has been identified as one of the main causes behind the extensive damages reported to the forestry lots (Andersson et al., 2018).

Despite after such awareness-raising the local communities started the promotion of risk-spreading strategies in the process of reforestation after the storm through consultations and grants supporting the plantation of other trees species, such efforts remained almost unheard. Indeed, no impacting change of species has been reporting within the reforestation process after Gudrun, with Norway spruce still occupying the 90% of the replanted area, since it is the most profitable and highly demanded tree specie within the market (Andersson et al., 2018).

As it emerges, although the direct experience of weather-related hazards, the high dependence on the path of profitability has not led the way for the adoption of different, more sustainable approaches: in general, all the adaptation strategies which do not challenge the above mentioned production system are more likely to be chosen, and so the efforts in promoting innovations in forestry management schemes have been largely downplayed by the Swedish forest industry (Andersson et al., 2018).

The worrying fact is that such downplaying would thus imply that taking the risk in the name of traditions and economic profit is then acceptable as long as the damage is repairable or, in our case of damaged forests, *"replantable"* (Andersson et al., 2018).

Such circumstances are finding their empirical evidence in reforestation results after Gudrun's passage: not a minimum change in forestry strategies has been detected, because of the high level of path dependence driven by profitability and lack of shared forestry innovations within the management framework (Andersson et al., 2018).

As many forest owners reported, institutional bodies and forestry professionals – especially those who are owning big properties only for profit but do not live on-site – have framed extreme windstorm events just as an unavoidable risk and therefore, any change or adaptation measure proposed is seen as simply needless (Andersson et al., 2018).

Within this framework, it is therefore appropriate to ask what kind of response has been undertaken by individual forest owners to tackle the limitedness and staticity of such forestry approaches.

Since the experience with Gudrun has brought a wider awareness among the community of small forest owners, in the first place with the challenging issue of species' revising, the number of professionals who started questioning the dominant economic rationale overarching the forestry model started increasing (Andersson et al., 2018).

In contrast to the well established position of such business-as-usual model within the forestry sector, the interviewees reported that they started the so called "micro-level resistance" (Andersson et al., 2018) which consists in articulating and promoting alternative rationales other than the economic one, in order to overcome the static pillars of forestry management regulations. On the viewpoint of community' resilience, this has meant a great commitment in terms of hands-on action, since forest owners are day by day more worried about the social and economic implications of the storms on their forest ownership.

So in the first place, they started arguing about the traditional specie's choice for planting, namely the Norwegian spruce which has largely demonstrated being the most storm-sensitive forest-type (Andersson et al., 2018). They started calling for a more reflexive practice of forestry, for example, starting trying new species and harvesting methods like switching to broadleaf forest as it was originally, or trying to take advantage of the small-scale forestry companies by investing in quality and range of trees' choice instead of insisting on the most economically profitable one (Andersson et al., 2018).

The overarching aim of such "micro-level resistance" is to primarily decrease the sensitivity of forests to heavy windstorms, which could become possible through the increase in the variety of planted species in the same forest (eg. birch, pine and spruce) or even through the switching from clear-fellings to selective fellings. In these ways, there should be chances to grow a forest with a big age difference and therefore, decrease its sensitivity to climate hazards and increase the system's durability in the long run (Andersson et al., 2018).

Another important aspect commonly shared within the interviewees is that such micro-level resistance focuses above all on the importance of integrating and emphasising other values for the forestry sector: not only the economic and profit-oriented one, but also the cultural one which embrace local forestry cultural traditions and takes into account the local intergenerational know-how which could valuably contributing to increase the quality of small-scale production (Andersson et al., 2018).

Overall, what can be drawn from this study is how static and uniform risk management approaches can hinder the development of innovations in the field of forestry adaptation strategies. Indeed, the process for implementing innovative and alternative measures might require more flexible models in line with the social and environmental diversity as well as the related needs which are far more than the mere economic discourse (Andersson et al., 2018).

4.3 CASE STUDY 3: WINDSTORM KLAUS

4.3.1 ECONOMIC ASPECTS OF WINDSTORM KLAUS

The paper published by Caurla, Garcia and Niedzwiedz published in 2015 and titled *"Store or export? An economic evaluation of financial compensation to forest sector after windstorm. The case of hurricane Klaus"* offers an illuminating insight on how economic and financial measures could affect both the functioning of the market and the main actors involved in the consequences of a windstorm such as private forest owners, processing industries and transport companies operating within the forestry sector. One of the major bottlenecks emerged in this research field is that so far, impact assessments have been carried out mainly under the perspective on how public compensation policies influence forest owners' risk management decisions and currently, it can be stated that very few studies have been done on the impacts that such compensation programmes have on the forestry sector as a whole (Caurla et al., 2015). The above mentioned study was then conducted with the aim of filling these gaps in the literature, taking the case of the extreme windstorm Klaus as reference, which in January 2009 hit the south-west of France, particularly the Aquitaine region, which reported the majority of storm's damages (95%), for a total financial loss estimated around 1,34 -1,77 Bn EUR (Caurla et al., 2015). The amount of timber destroyed by Klaus was over approximately 42 Mm³, of which 37,1 Mm³ were maritime pine stands: the support measure set in place by the French government was the allocation of an economic compensation plan for the recovery amounting to 138 M EUR, 12,5 M EUR of which in the form or subsidized rate loans, 25 M EUR in storage areas subsidies, 56 M€ in transport subsidies and ultimately, 46 M€ in shipment subsidies (Caurla et al., 2015).

As previously assessed, when an extreme windstorm occurs, one of the major economic threats for the forestry sector, is the risk that windfall wood prices drop to zero.

In order to understand the impacts of possible compensation strategies set in place in the aftermath of windstorm Klaus, the study based its analytical approach on a bio-economic partial equilibrium model framework [2], namely the French Forest Sector Model (FFSM), comparing the data from the governmental financial compensation plan with alternative plans, assuming alternative subsidies' distributions between storage and transport options (Caurla et al., 2015). This approach of comparing the negotiated recovery plan after Klaus with other possible scenarios was aimed at providing insights on how the different outputs would have affected the market and the many stakeholders operating within the recovering forestry sector (Caurla et al., 2015).

In addition to the results of the model simulation, which will be reported below, a worthwhile aspect of this analysis is the use of the above mentioned FFSM, as it could be an important contribution to innovation and improvement in windstorm damage management and adaptation strategies.

At its theoretical base, the FFSM has the same partial equilibrium structure as the existing global forest sector models – e.g. the Global Forest Model, the Global Forest Product Model or also, the Global Trade Model (Caurla et al., 2015).

It consists of two interdependent modules, as shown in *fig.12*, which are respectively a forest dynamics module (FD) and an economic market module (E). The E module, at each year, given available timber resources, timber supply functions, transformation capacities and technologies as well as the demand function for timber products, computes all market equilibriums within the given forest sector, deducing the annual harvest. This latter data then enters the FD module which computes the available timber resources at year t+1, that then re-enter the E module, and so on, making possible the simulation of different scenarios and investment strategies (Caurla et al., 2015).

However, what differentiates the FFSM from others, and what makes it interesting within the context of this analysis, is its specificity with respect to the forestry characteristics of the territory, which can be summarized in these three main points (Caurla et al., 2015):

1. the FFSM model focuses only on the 22 French administrative regions;
2. the FFSM models international trade assuming a condition of imperfect substitution between domestic and foreign products;
3. the FFSM biological module captures French forest specificities, especially regarding the inter- and intra-regional diversity in species and silvicultural practices.

[2] Partial equilibrium implies that the analysis only considers the effects of a given policy action in the market(s) that are directly affected. The analysis does not account for the economic interactions between the various markets in a given economy. In a general equilibrium setup all markets are simultaneously modelled and interact with each other.

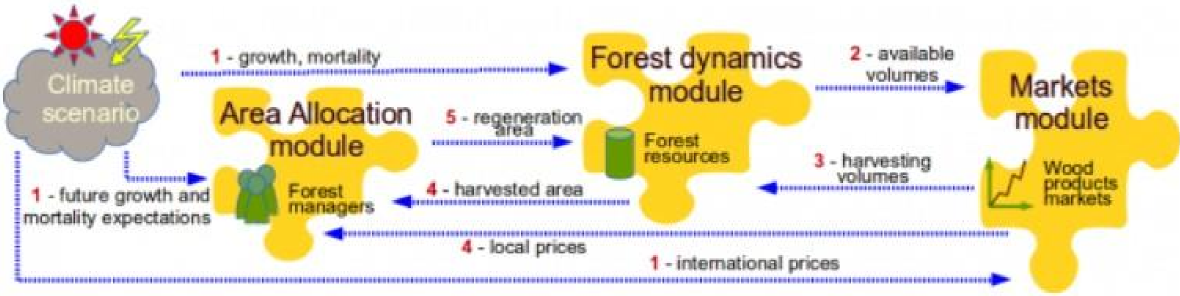


Fig.12 *Illustration of the natural and anthropogenic determinants which constitute the simulation modules of the FFSM. Source: https://ffsm-project.org/wiki/en/home*

In the case of storm Klaus, and in the study of the economic impact of the recovery measures set in place by the French government, the specificity of such model allowed the elaboration of valuable data and proved also to be a relevant supporting tool from the perspective of institutional policy making (Caurla et al., 2015).

Considering above all the diversity of French forests in terms of climate, soil, species and type of management, the FD module of the FFSM was able to break down the timber resources into 1716 cells - which differs by administrative region - allowing accurate simulations and forecasts, based on the natural and anthropogenic specificities of the territory examined (Caurla et al., 2015).

This peculiarity turned out to be very useful in the framework of the analysis of the impact of Klaus in Aquitaine in 2009: in addition to the negotiated recovery plan, three other comparison scenarios were considered, namely a scenario with no financial compensation plan, a scenario with the highest share of investment in storage measures and one with the highest share invested in transport solutions, as shown in *fig.13* below (Caurla et al., 2015).

	Storage in storage areas Mm^3	Supply for direct consumption in processing industries Mm^3		Export abroad Mm^3	Total Mm^3
		In the Aquitaine region	In other French regions		
"Without a plan" scenario	7.14	5.19	7.47	5.2	25
"Observed" scenario	10.16	3.22	7	8.66	29.04
"Transport" scenario	6.56	3.34	6.89	12.15	28.94
"Storage" scenario	13.25	3.25	6.99	5.37	28.86

Fig.13 *Total windfall supply for the 2009–2020 period and its distribution among storage, direct consumption and export abroad.*

The main results of the economic evaluation of financial compensation to the forestry sector are presented below (Caurla et al., 2015):

1. the negotiated compensation scheme for Klaus, in contrast with a scenario in which there is no plan appeared to have hastened windfall supply. The investment strategy raised the overall volume of delivered windfall by 14% when assuming a 5% annual degradation rate. Furthermore, the "observed" scenario *(fig.13)*, prioritized on-site storage and export abroad compared with a "no plan" situation which supported direct consumption of windfall;
2. when the storage proportion is increased, the price-drop after the hurricane is lessened. However, when compared to the "transport" scenario *(fig.13)*, the price rebound is likewise delayed in the "storage" scenario. The trade-off between these two has therefore a significant impact on the social acceptability of plans, making these two outcomes policy-relevant.
3. at the global level, the analysis raised questions regarding the political economy of storage strategies. Indeed, according to the simulation results, the storage-oriented policy is expected to harm wood producers' surplus, particularly in other French areas other than Aquitaine. Increased storage, on the other hand, appears to be plainly beneficial to both consumers and storage sector. As a result, the socially acceptable storage proportion should be calculated through a negotiation process based on these two detected effects.

The results and simulations carried out thanks to a tool that takes into account the data of the territory and its specificities, certainly represents an interesting potential for the decision making process of the various stakeholders involved, as it can help, for example, windfall wood suppliers within the affected communities in the choice of exporting their windfall abroad, to other French regions, storing it or even, it can support regional and local institutional bodies in the choice of the financial amount to invest for storage plans or transport plans in the aftermath of the windstorm.

Using a tool like this, with a potential for analysing the territory on a local level, could largely help in developing better-tailored impact assessments on the forestry sector as a whole, without neglecting territorial specificities as well, and could also complement and improve policy and institutional decision making on risk management and adaptation strategies.

4.4. CASE STUDY 4: WINDSTORM VAIA

4.4.1 INSTITUTIONAL ASPECTS OF WINDSTORM VAIA

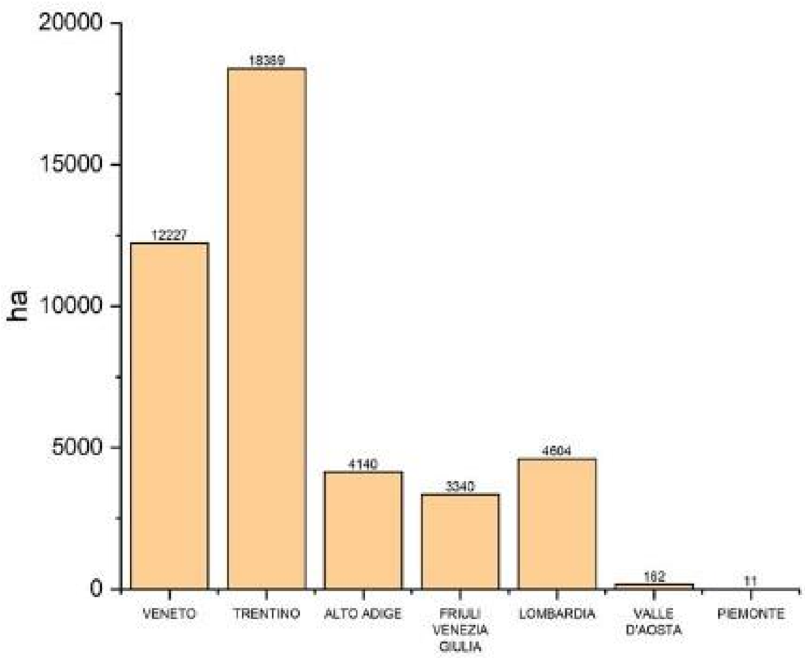
On October 29th, 2018, north-eastern Italy has experienced - at the tragic expense of its forests - what has been recognised as the most impactful event on forest ecosystems ever recorded on Italian territory to date (Chirici et al., 2019): the windstorm Vaia.

During its path over the Italian territory, Vaia's wind gusts exceeded the speed of 200 km\h, causing intense damages and destruction to over 42,500 ha of forest stands, which then resulted in approximately 8.5 Mm^3 of windfall trees (Motta et al., 2018).

The most affected regions by storm Vaia were Trentino Alto Adige and Veneto, followed by Lombardy, Friuli Venezia Giulia and, marginally, Piedmont and Valle d'Aosta as well. As shown in *fig.14*, the most severe damages to forest were reported within the regions of Trentino Alto Adige and Veneto, accounting respectively to 18.369 ha in Trentino Alto Adige and 12.227 ha in Veneto Region (Chirici et al., 2019).

Within the immediate aftermath of Vaia, the national Forestry Directorate (DIFOR) which is part of the Ministry of Agriculture, Food, Forestry and Tourism (MIPAAFT), reacted to the emergency by convening a special working table that included the involvement of various key players within the territories such as local authorities, research bodies and universities, with the primary goal of collecting the data necessary to draw up an initial estimate of the damage caused by Vaia (Chirici et al., 2019).

Specifically, they were asked to assess and submit estimates of the respective areas affected by the windstorm, and the amount of fallen timber, in order to quickly lay the foundations for coordinating interventions, and to begin preparing economic support packages. Each region started its own assessment operations independently, although the overarching mission was still to collect and share data with the working table, within which GeoLab, research institution in Florence played an important coordinating role in harmonising the data provided by each institutional body and then making estimate results available to the various stakeholders involved within such process (Chirici et al., 2019).



In total, 494 italian municipalities have reported damages following the passage of Vaia windstorm, involving a territory of approximately 2,306,968 ha (Chirici et al., 2019).
With such a vast territory damaged, how was the post-disaster situation handled?

Fig.14 *Forest damages in ha, reported within north-eastern Italy after Vaia windstorm. Source: Forest@ Journal*

With regard to the many approaches adopted by the regions involved, in addition to the support provided by the information already present in their respective databases, it can be observed (Chirici et al., 2019):

- perimeters of the single fallen trees lots for the autonomous provinces of Bolzano and Trento, Friuli Venezia Giulia, Piedmont and Valle d'Aosta;
- windfall trees estimates already merged on the basis of administrative units for the regions of Lombardy and Veneto.

Most of these perimetrations were carried out by means of on-site surveys in the affected areas, assisted by helicopter and drone flyovers to allow then for photointerpretation of the material collected.
Another approach applied during this first emergency phase, and which proved fundamental for the rapid acquisition of preliminary information on the extent of the damage suffered by the territories, was the use of satellite mapping techniques - in this specific case, Sentinel 2a and 2b, used for the damage-mapping in Lombardy - which played a key role in identifying the areas affected by Vaia within the first five days after the disaster, even though given the limited spatial resolution it was not possible to map accurately the most damaged areas (Chirici et al., 2019).
Together with the activities of the national working group, the Copernicus Emergency Mapping system was also activated in order to collect further data, even if due to the heavy cloud cover

present the days after Vaia, the system was able to map only some portions of the damaged areas totalling around 4000 ha (Chirici et al., 2019).

Although these approaches had some operational limitations, such as resolution problems or the lack of accurate data in the case of cloud cover, snow or shadows, they still proved to be valuable supplementary tools to the ongoing field works.

In fact, despite the partial data collected by the Copernicus system, it was nevertheless possible to create maps with different information on the extent of damage, illustrated below, respectively (Chirici et al., 2019):

- *Fig. 15*, which shows clusters of red dots, each corresponding approximately to 6 ha of damage caused by Vaia, calculated on a municipal basis;
- *Fig. 16* shows the total area in ha, again divided according to a municipal basis, that was destroyed by the storm, where the colours, ranging from dark orange to bright red, represent the worst affected areas, which vary from 43 ha to 1177 ha and are mainly concentrated in Trentino and Veneto region;
- *Fig.17* shows the percentage of municipal area destroyed during the storm, where again the serious situation in the Trentino and Veneto regions stands out.

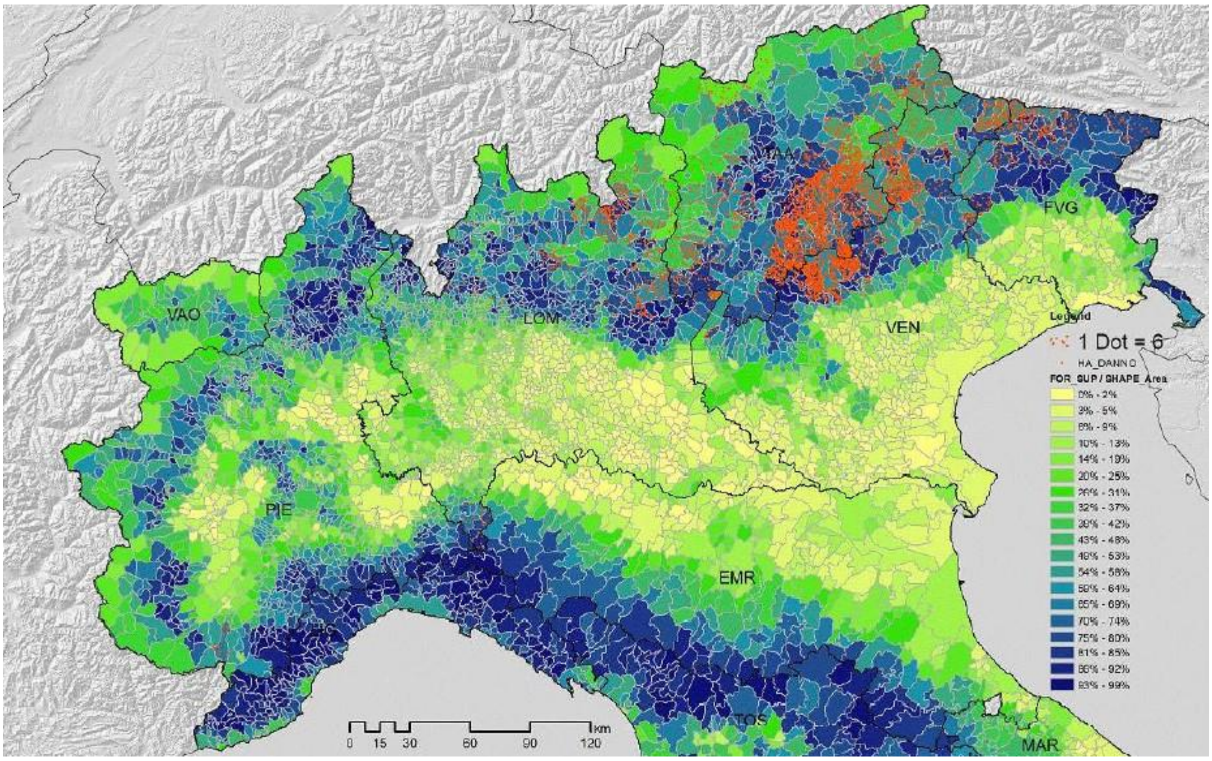


Fig.15 *Representation using Copernicus data of the forest coefficient per municipality and the impact area of forest damage caused by Vaia. Source: Forest@ Journal*

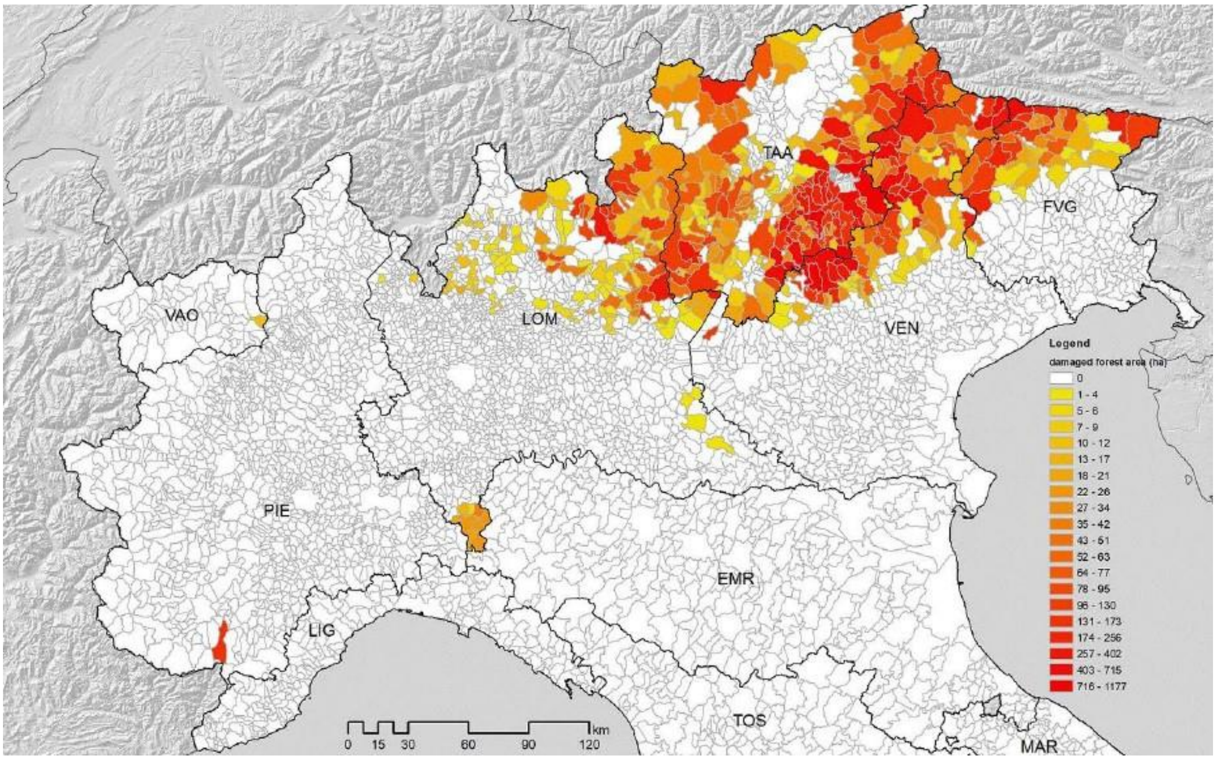


Fig.16 *Forest area destroyed by storm Vaia per municipality. Values in ha. Source: Forest@ Journal*

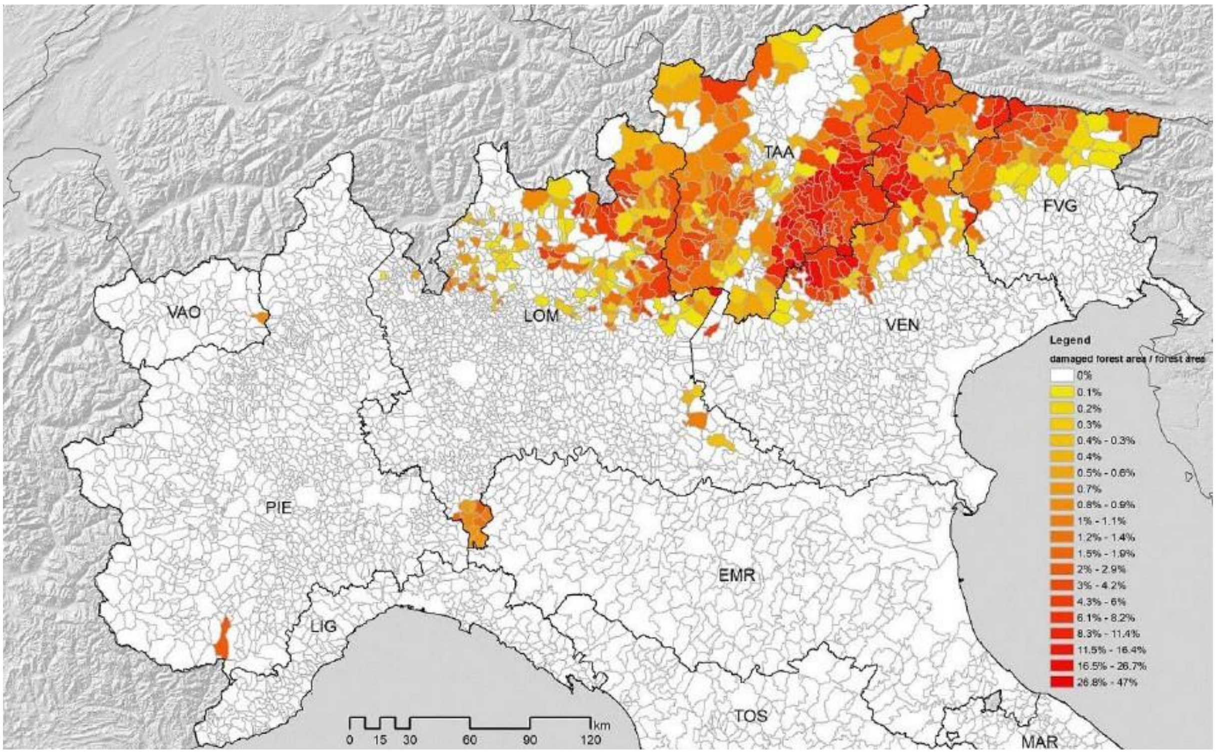


Fig.17 *Percentage of forest area destroyed by storm Vaia. Source: Forest@ Journal*

What were the results and consequent steps of action taken following the acquisition of these data? After the initial information-gathering operations on the effects of Vaia facilitated by the joint participation of the many stakeholders involved, the damage caused by the windstorm was estimated at approximately EUR 2.9 billion in total (Motta et al., 2018).
At the institutional level, the Italian government then acted by declaring the state of emergency for the regions affected by the storm Vaia, with a resolution of the Council of Ministers on 8th November 2018 (GU Serie Generale n.266, 2018).
Subsequently, with the law of 30th December 2018, art. 145 par. 665, the first emergency support measures were defined for both public and private entities affected by the damage of storm Vaia. Specifically, the law established a voucher reimbursement of up to 50% of the costs actually incurred and documented for the removal and recovery of windfall trees, up to an overall maximum expenditure limit of EUR 3 million for the year 2019.
In order to shorten the timeframe for the management and implementation of the post-windstorm support measures, as well as to lighten the bureaucratic processes, the Italian government explicitly designated the body of the National Civil Protection as the key actor for coordinating and implementing the interventions carried out within the framework of the state of emergency, as provided for by the legislative decree of 2nd January 2018 (Gu Serie Generale n.17, 2018).
Subsequently, through an ordinance of the Head of the Civil Protection Department (Ordinanza n. 558, 15th November 2018), with specific reference to the Vaia catastrophe, the presidents of the regions affected by the extreme windstorm were then appointed as delegated commissioners, namely bodies of the state autonomous from the region, with the aim of managing the financial resources for the Vaia emergency more quickly and efficiently.
The resources allocated to the delegated commissioners came from the National Civil Protection Fund, which was responsible for providing financial support for emergency works carried out in the days following the extreme event and the first support measures for the population and the recovery of the many businesses affected (Ordinanza n. 558, 15th November 2018).
The combination of these institutional measures rapidly undertaken following the serious destruction caused by Vaia, clearly shows how there was an intention on the part of the national government to favour a local management approach, in order to better direct the investment plan for post-emergency works, since in addition to the immediately visible damage, other possible major risks such as landslides or flooding were also considered.
Finally, it is also interesting to note the bottom-up approach of the collaborations between the many institutional and non-institutional bodies operating at the local level in the affected

territories, creating a synergic action with the regional commissioner administration set up for the emergency.

Among the main actors that have been involved in the post Vaia operations we can observe, for example (Report Protezione Civile Nazionale, 2020):

- Municipal administrations and territorial Unions, Mountain Communities, Reclamation Consortia, i.e. subjects that are generally involved in the management of public assets
- the Chambers of Commerce, appointed Actuating Subjects for the management of contributions and financing to businesses post Vaia emergency (Order No. 558, 15th November 2018);
- private citizens and businesses that have suffered damage and have requested contributions and financing for repairs and increasing the resilience of structures;
- the professionals and enterprises that through technical services assignments and works contracts collaborate in the implementation of the interventions of the Deputy Commissioners' investment plans.

4.4.2 OTHER ASPECTS ON WINDSTORM VAIA

As seen in the previous section, storm Vaia represented an unprecedented shock for the Alpine forests of north-eastern Italy. Even more so, if we consider that the vast area affected, the Dolomites, represents a landscape and biodiversity heritage recognised and protected by Unesco since 2009 (Dolomitiunesco, 2009).

Many places that represented not only a wealth of biodiversity, but also familiarity and security for the many local communities, have dramatically changed their environmental physiognomy *(fig.18)*.

Fig.18 *Carezza Lake (BZ) landscape scenario in the aftermath of Vaia (BZ) Source: Predazzoblog.it*

This extreme climatic event, however, has also left something positive beyond its obvious trail of destruction: the opportunity to bring to attention the need to reflect on, and discuss, a different approach to the management of the forests and its ecosystem services, in a different key from the past (Lasen, 2019).

First and foremost, and certainly to be considered, is the fact that natural resources and ecosystems represent a valuable capital which shouldn't be marginalised in post-storm reconstruction processes, especially within unique and fragile ecological and landscape contexts, since considering only the economic and profit aspect is limiting and does not allow for a long-term overview of forest development (Lasen, 2019).

This automatically leads to another important fact: natural resources are finite, and their renewal capacity takes place over long periods of time that are less and less compatible with the pace of current consumption (Lasen, 2019).

The ecosystem damages caused by Vaia have been extensive, so calculating their medium- to long-term effects is very difficult (Motta et al., 2018).

And it is precisely in view of these challenges within the assessment of ecosystems' damages and the UNESCO-protected mountain landscape, that Vaia represented the trigger event for greater awareness at the institutional level, clearly showing the impellent need to develop an appropriate forest ecosystem monitoring plan (Lasen, 2019).
A coordinated plan to facilitate the assessment of the evolutionary dynamics that will be triggered in the post-storm scenario, taking into account the different situations at the local level within the destroyed areas, affected communities and previous land uses.
A plan that breaks away from the economic-utilitarian vision of the territories and protected areas, in favour of a more sustainable and conscious vision, in which the conservation of ecological balances is more consciously valued (Lasen, 2019).
Within this context of 'rethinking the forest', the Habitats Directive and the Natura 2000 network for the conservation and protection of territorial biodiversity have provided an important framework for positively influencing a local approach to nature conservation.
From the institutional viewpoint, in the framework of the post-Vaia recovery plan, an investment plan dedicated to forest monitoring and enhancement of the damaged territory has been formulated, through a protocol of the MIPAAF (n.9093602, 2019), in which a sum of 3M euro has been allocated from the 2019 Italian Forest Fund allocations, of which 300,000 euro dedicated to the monitoring plan of the territories affected by Vaia, and 1,700,000 euro dedicated to the protection and enhancement of monumental trees.
The resources have been allocated to the regions and autonomous provinces affected by the disaster to support them in monitoring not only the state of restoration of the sites and the activities related to the mitigation of the hydraulic and hydrogeological risk, but also the biological evolution of the forest ecosystems altered by the climatic hazard.
Moreover, in order to foster the harmonisation of the intervention's methodologies at a local level, a special Technical Committee was then set up with the task of providing the indications and directives for carrying out the planned monitoring activities (MIPAAF, n.9093602, 2019).
In conclusion, in addition to estimating the economic damage caused by the storm, it is also important to consider in an integrated manner the aspect of ecosystem services and the value of naturalistic quality, which is generally a rather marginalised issue, especially in the emergency decision-making phases where the focus is generally on the aspects of economic restoration (Lasen, 2019).

4.5 PRELIMINARY FINDINGS AND OBSERVATIONS FROM THE ANALYSIS OF THE FOUR CASE-STUDIES

One of the primary objectives of the literature review was to search for valuable good practices and methodological frameworks that could be shared in order to improve the ways to approach and manage windstorms' consequences at European level, as well as analysing the role of institutional and non-institutional actors within the local decisional process concerning disaster risk management.

Then, in the previous section presenting the four cases of extreme windstorms in Europe, many interesting insights emerged during the analysis, both on the front of potential good practices that could be shared and on the front of the multi-level dynamics examined.

Before proceeding to a detailed discussion of such aspects, the following *table 3* summarises the main key approaches found in coping locally with windstorm effects.

As reported in the "area of interest" column, it is important to emphasise that for the four storms examined, it was not always possible to analyse the social, economic and institutional aspects for each case study, as the literature on the subject is still young and lacking in harmonised data, so on average only one or two key issues per case were dealt with (Caurla et al., 2015).

From another point of view, however, this observation also allows for another important consideration to be made, namely that the dynamics in these areas of interest are often deeply interconnected and consequently, the dynamics have been studied and analysed in a jointed manner.

Here are the first observations that can be drawn from the four windstorm cases studied.

At a general level, the emerging picture is that each country examined adopts different methodologies and approaches in managing the effects of windstorms.

Although theoretically, approaches and methodologies for action in this regard have been developed at the international level (IPCC, 2012; Gardiner et al.2013, Riguelle et al., 2016; EEA, 2017), in practice such policy making tools are not adopted systematically and uniformly within the examined countries affected by this type of event.

From a general point of view, therefore, the course of action taken in individual cases is fragmented and varies from country to country. Consequently, it was not possible to determine any particular differences in management between countries that are already accustomed to windstorms and those that are not, as the choice of tools and approaches varies greatly.

Nevertheless, it was possible to observe many innovations and valuable methodological approaches within each of the areas of interest examined by the analysis, and what is relevant to observe above all, is how all these innovative responses with respect to the theoretical reference methodology, took shape precisely from the specificity of the local dimensions.

For example, when analysing the social aspects, it emerges that community actors and their inherent social capital can be an influential factor in creating effective, place-based approaches in response to windstorm destruction.

An example of this is the case of windstorm Lothar in Germany where the FFEs' forest owners, in order to manage the extensive damage caused by the windstorm, took the strategic decision to rely significantly on the self-processing of damaged forests by actively involving family members and neighbours, reducing in this way expenditures for external help, investing money inside their activities and keeping it viable in spite of the substantial damages (Hartebrodt, 2004).

Or again, the aspect of place-based efficiency is found in the case of the small rural communities in Southern Sweden after the passage of windstorm Gudrun, who through their micro-scale resistance aim at changing a profit-oriented forest management model, trying to push towards a more sustainable vision of their forests and market by adopting different forestation techniques than the dominant institutional forestry logic (Johannisson and Olaison, 2007).

It must be emphasised, however, that despite the virtuous potential found in local management strategies, there is still necessarily a need for integrated support through the recovery financial plans implemented by the institutional authorities.

And precisely with regard to this aspect, it can be said that this sphere probably represents the most controversial one taken into consideration: in fact, if on the one hand there are virtuous approaches that offer innovative systems for improving the efficiency of institutional decision-making processes as in the case of the rapid and participatory damage mapping of windstorm Vaia (Chirici et al., 2019) or the French Forestry Sector Model of windstorm Klaus (Caurla et al.,2015), on the other hand, it emerges a picture of a set of institutional bodies that are detached from the local realities directly affected from the effects of windstorms, as particularly marked within the case of windstorm Gudrun in Sweden (Andersson et al., 2018), and that tend to marginalise the participation and, as a consequence - the potential great resource - of local actors, hindering and slowing down real opportunities for active participation in policy-making processes. This institutional inefficiency found especially within the case of windstorm Gudrun actually represents a challenge of common interest, as the synergies between institutional and non-institutional actors that develop at the local level are likely to play a key role within decision-making processes as they can add in valuable experiences and knowledge of the territory, resulting in more effective approaches.

As seen, for example, in the case of windstorm Vaia, fostering active multi-disciplinary and multi-level participation that starts from the affected dimension, the local one, allows for the design and implementation of better approaches, as this case shows, making possible to obtain a preliminary mapping of the damage in only five days after windstorm Vaia's passage, thanks to the joint action of a wide range of actors at different levels of the territory (Chirici et al., 2019).

On the other hand, as regards the economic aspect, the analytical picture that emerges highlights the major challenges inherent in the lack of harmonised data at an international level, which may be partially attributed to the fragmentation of institutional and non-institutional collaborative work at the local level. At the same time, however, interesting examples of models concerning damage estimation and management can also be noted, such as in the cases of storm Lothar in Switzerland with the Decision Aid Manual or again, the French Forest Sector Mode of storm Klaus in France, both of which representing place-based solutions, that could be scaled up and adopted within other local contexts as well.

The set of these analysed areas of interest really offers a lot of relevant insights into the potential, challenges and limitations encountered during the study, which will be explored in detail in the following section of the discussion.

WINDSTORM EXAMINED	AREA OF INTEREST	COUNTRY	KEY- APPROACHES DETECTED TO COPE WITH WINDSTORMS EFFECTS
Lothar (1999)	socioeconomic	Germany	Community resilience in the German Black Forest: social innovations from Farm Forestry Enterprises
	Economic and institutional	Switzerland	Decision Making tools improving institutional performances in windstorms damage management: the Decision Aid Manual
Gudrun (2005)	social	Sweden	Emergency entrepreneurship among communities and social capital in balancing local windstorms effects
	socioeconomic	Sweden	Micro-scale resistance and adaptation of small forest owners to cope with windstorm effects within the local community and the selling markets
Klaus (2009)	economic	France	Policy-relevant tools for the economic recovery post-windstorm: the French Forest Sector Model
Vaia (2018)	Economic and institutional	Italy	Institutional responses to face windstorm effects at the local scale: innovative approaches of data gathering for damage assessment and bottom-up decision making
	institutional	Italy	Beyond a windstorm's destruction: opportunities to rethink forest policies improving forests' monitoring plans integrating the sustainability thinking

Tab.3 *Table indicating the main key-approaches to cope with windstorms effects detected within the literature review*

5. DISCUSSION

This section is organised on the basis of the main themes that have emerged as relevant from the analysis of the three dimensions, the social, economic and institutional one that have been explored in the four selected cases. These themes are, namely: 1) social capital, 2) types of institutional responses and 3) mechanisms of economic management of windstorms.

Such themes are guiding the flow of decision making and actions undertaken at local level within the various cases, and thus are reported here for extracting lessons to learn.

The following discussion attempts to involve all their facets and different implications and interconnections with the various dimensions.

5.1 SOCIAL CAPITAL: THE LOCAL ASSET TO COPE WITH WINDSTORMS' EFFECTS

To begin with, when analysing the disastrous effects of a windstorm, what emerges as general evidence is that the social component is often marginalised within the strategy-design processes, in favour of a greater focus on the economic contingencies (Hartebrodt, 2004; Johannisson and Olaison, 2007; Anderson et al., 2018).

It should not be forgotten, however, that in the scenario of a windstorm, it is the local communities that are directly affected by the hazardous events in the first place, so within this context the social component presents the greatest weakness in terms of risk exposure and thus, vulnerability.

It is also true, however, that as emerged within the case-studies analysed, local communities are capable to bring potential enormous value in terms of social capital, knowledge of local social networks and local know-how within the post-windstorm decisional processes.

Within each of the four cases territory, the inner social capital of communities manifests itself in different forms, creating interesting insights for the study of local responses to windstorm threats. For example, in the case of windstorm Lothar in 1999, it was very surprising to note how the spontaneous decisional processes undertaken by small-scale forest enterprises within the communities of Baden-Wurttemberg made it possible to sensitively reduce the reported economic consequences to their businesses by relying on the intense collaboration from the familiar and neighbouring network (Hartebrodt, 2004). Precisely, such occurrence refers to the farm forestry enterprises (FFEs), namely small local businesses very diffused within this German region which were mainly family-run, and during the occurrence of windstorm Lothar were the type of regional forestry business who suffered the most severe damages (Hartebrodt, 2004).

The owner's choice of relying mostly on the internal help of families and neighbours for clearing operations instead of turning to external assistance has proven to be a successful policy in coping with the windstorms' effects at the local level, since it has been demonstrated that via such strategic investment decision, a difference of about 30 M euros was retained by the FFEs compared to the other type of forestry businesses which got an external help for clearance or reconstruction operations (Hartebrodt, 2004).

Additionally, such investment policy performed by the FFEs led to the opportunity for internal investments in clearing tools and machineries which made such forestry businesses capable of maintaining their economic viability in the aftermath of the emergency phase after Lothar's passage (Hartebrodt, 2004).

Within this case, the local social capital has shown its value as proactive approach for action within the decision-making system of the small businesses community, demonstrating the importance of making the most of local social resources before resorting to external interventions, that as seen *(Fig.11),* may instead increase the total costs incurred and could therefore undermine the viability of local small business.

Other important considerations on the value of social capital can be also drawn from the case of windstorm Gudrun in Sweden in 2005. In this case, the violence of the extreme storm caused severe damages in the south of the country, among which, the total isolation of many small communities. Within this context of great infrastructural and communication disconnection, local social capital arose in the form of the so-called "emergency entrepreneurship" (Johannisson and Olaison, 2007).

This concept refers to those social processes by which, in an emergency situation, local knowledge and territorial leadership combine into a collective effort towards a process of actions and interactions to address the commonly shared emergency situation (Johannisson and Olaison, 2007). In this specific case, as windstorm Gudrun cut communities off from the possibility of immediate help from outside, people exploited their networks of trust created through bridging and bonding capital, organising alternative - and in some cases, quite creative - solutions to cope with the management of the territorial emergency. Examples include local private companies making their machinery available to facilitate infrastructure recovery and clearing operations, other private companies or citizens providing their own power generators to communities as the main grid was completely destroyed, or also, retired ex-cooks doing their utmost to supply hot food to community citizens involved in the clearing operations 24\7 for almost a week.

Starting from these examples, what is important to highlight is how in the aftermath of the windstorm, within such small communities there is no distinction between public or private,

citizen or institution, but commonly shared willingness to cope with the local ongoing emergency.
That is to remark how thanks to social capital, different formal and informal structures at the local level may enforce potential entrepreneurial initiatives and the consequent release of hidden social capital in the face of disaster (Bizikova et al., 2005).
Such positive facts represent valuable findings since they are proving that one of the key merits of social capital is that it may shift the focus of analysis from the individual behaviour to the pattern of relations between agents, social units and institutions, and such shift therefore offers a connection for a deeper understanding of micro-, intra- and macro-levels of analysis.
Thus, considering the local social capital within the management of windstorm damages, could also foster multi-disciplinary and multi-professional approaches, through its broad appeal and potential application.
This aspect was particularly evident in the case of storm Vaia, immediately after which, there was a major institutional effort for the involvement of a wide range of territorial actors with different specialisations, in order to contribute to the organisation of preliminary windstorm damage estimates (Chirici et al., 2019).
Such well-coordinated synergies made it possible to obtain preliminary damage mappings of the most affected areas in just five days, allowing then to formulate locally-oriented recovery and management plans, with the aim of involving as much as possible, a wide a range of local actors in order to implement these plans on-field taking into account the specificities of each territory and community involved (Chirici et al., 2019).
Starting from this example, it can be noted the added value that social capital could bring to local development dynamics, paradoxically precisely from a situation of local crisis. Because sometimes, it is precisely from an event that disrupts local routines, like a windstorm, that opportunities for growth, consolidation and resilience can arise, both within the community itself and between local communities (Bizikova et al., 2007)
Moreover, the same growth opportunity also applies to the relationships between the network of institutions at the local level, and between the community involved, allowing occasions for enriching policy-making processes with local knowledge and consolidate the active participation of communities within the territorial processes for the improvement of local development policies.
But if on one side social capital and communities represent key features for improving storm damage management strategies, on the other, there are still many factors hindering these processes. As seen in the paper by Andersson and colleagues published in 2018 concerning

again the case of windstorm Gudrun in Sweden of 2005, there are still many obstacles which are undermining the potential of social capital within local decision-making processes.
The most obvious example concerns the testimonies of small forest owners in the southern regions of Sweden, who represents the most severely affected category within the territory (Andersson et al., 2018). Many of them, interviewed after the passage of windstorm Gudrun, reported how the greatest difficulties they faced in the windstorm's aftermaths were mostly due to an outdated mindset that mainly takes into account the logic of profit, which is prevalent especially within the forestry sector's professionals and forestry institutions.
The fact that despite many violent windstorms repeatedly hit and destroyed the Swedish region, professionals still choose to continue reforestation practices planting the most vulnerable tree species because it is also the most profitable, is just one of many examples.
The underlying problem is that within this context, the fact that these windstorms could cyclically endanger the fruit of one's labour has been internalised as an unavoidable routine risk within the whole sector, and therefore adaptation measures are perceived as needles.
So, attempts to adopt approaches to safeguard and strengthen Swedish forests have been largely downplayed by forest industry, highlighting how path dependence driven from profitability translates into a general lack of forestry alternatives, at the expense of local communities whose subsistence mainly depend on their forest's wellbeing.
But in light of the spreading awareness among the small forest owners concerning the need for providing alternative approaches to cope with such natural hazards, especially to mitigate the risks and limitations associated to the prevailing forestry model, they started challenging those "taken for granted" truths (Andersson et al., 2018).
Within the area affected from windstorm Gudrun, small forest owners started practicing the so called "micro-level resistance" (Andersson et al., 2018), meaning the production of alternative forms of forestry approaches, highly in contrast with the established profit-oriented position of the Swedish forestry's structure. The main goal of such emerging tendence is to spread their locally acquired knowledges through alternative rationales and discourses which actually are taking into account not only the economic variable but also other meaningful aspects such as the climate change threats and the issues of climate mitigation and sustainability.
Indeed, small forestry communities who are working in their forests on a daily basis and directly experienced in multiple cases the risks and limitations of not having better adaptation approaches, have no longer a purely profit-oriented perception because after much storm damage, it is more than agreed that there is a need for providing alternative reforestation and management techniques in Swedish forests (Johannisson and Olaison, 2007).

What the Gudrun's case brought about is that it clearly emerged the dissent of small communities for the top-down approach adopted by the forestry institutional representatives acting upon the rationale of profitability: this situation stimulates then an interesting reflection on the actual importance of having an active involvement of local actors and the added value they could bring in with their local social capital, especially within the strategic decision-making processes in risk management and the related policy design.

5.2 INSTITUTIONAL RESPONSES TO WINDSTORMS' EFFECTS

This last point shifts then the attention over the role played by the institutional component within such processes: indeed, what can be observed starting from the windstorm Gudrun's example is that usually, when it comes to the structure of decision-making processes concerning the management of extreme windstorms, the interaction level among stakeholders appears to be quite fragmented (Brundl and Rickli, 2002; Hartebrodt, 2004; Johannisson and Olaison, 2007; Anderson et al., 2018).

The above noted tendency (see section 5.1) of institutional bodies to favour developmental models focused on the rationale of profit and market competitiveness, certainly represents one of the biggest obstacles within institutional dialogue and strategy-building processes.

Since this profit-oriented tendency does not take too much into account other complementary variables such as risks deriving from climate hazards or the sustainability of the business model itself, this represents an element of potential exclusion or marginalisation for stakeholder's positive interaction, as just seen for the case of windstorm Gudrun in Sweden.

Therefore, this aspect is even more emphasized in those cases where local actors with little decisional power are openly objecting the rationale of such approaches (Johannisson and Olaison, 2007).

Another influencing feature of such dialogue fragmentation is represented by the geographic distance between central institutions and local realities: the geographical distance of the former regarding the different specific situations across the territory inevitably limits the direct knowledge-gathering and therefore, it constitutes a further factor of marginalisation from decision-making processes (Anderson et al., 2018). As consequence, this set of features often leads to the design and implementation of uncoordinated and fragmented strategies, ending up as a major source of policy inefficiency which then reports negative results in its territorial application. Within these circumstances, the rationale of *"one measure fits all"* (Anderson et al., 2018) does not apply successfully, as seen in the case of windstorm Gudrun in Sweden, where the relevant forestry institutions continued to promote reforestation operations after the

heavy windstorm destruction by encouraging forest owners to replant the tree species more prone to be windthrown, just because it was also the most profitable one.
This institutional rigidity resulting mainly from path dependency leads to a fragmented approach, and this represents the most challenging bottleneck within this context: it is important to highlight such structural limits, because within the management of windstorm effects, a more inclusive dialogue proves necessary, starting from the institutional side.
What can be indicated to address such challenges is a shift of strategy: indeed, adopting an integrated approach for managing windstorms effects would be an ideal solution as by definition, such strategy tool combines the analysis of several disciplines while simultaneously involving different types of actors, each with their own specific expertise (Riguelle et al., 2016).
On the very practical viewpoint, this would mean involving more stakeholders and disciplines at different levels in order to improve decision-making and storm damage management at the institutional level, as previously seen in section 5.1 for the example of Vaia windstorm.
Indeed, the management of storm damage risk and the related effects is characterised by a high level of complexity as well as by a high number of different variables to take into account, which differs according to the specific territories considered (Riguelle et al., 2016).
This type of approach therefore requires institutional flexibility, as well as a willingness to include and interact with all types of actors involved, in order to facilitate the gathering of the large variety of risks and effects left behind by the extreme climatic hazards.
Such approach is particularly useful for the setting up of different windstorm damages scenarios, because thanks to the determination of the system' scale, boundaries, inputs and outputs jointly with its associated risks, costs and benefits, risk mitigation strategies at the systemic level can be carried out (Riguelle et al., 2016).
Reducing the fragmented institutional dynamics is not a simple process, but this is certainly an appropriate way to proceed for improving risk management and mitigation strategies, especially in view of the key role that an adequate acquisition of knowledge can play directly from the areas affected by windstorm damage.
A positive example of institutional organisation was observed when analysing the case of windstorm Vaia in Italy from 2018. This windstorm of an unprecedented scale in terms of damage, severely affected the north-east regions of the country (Motta et al., 2018).
It was interesting to observe how the institutional response to this nationwide emergency was immediately oriented towards the local dimension of the affected territories.
After declaring the state of emergency for the regions affected by the storm Vaia (GU Serie Generale n.266, nov 2018), the national government designated the national civil protection corps as the key body for the coordination and implementation of the first emergency measures,

this in an effort to increase the efficiency of actions on field while trying to decrease bureaucratic burdens slowing down the operations (Gu Serie Generale n.17, 2018).

Then, the national civil protection corps appointed the presidents of the affected regions as delegated commissioners, with the aim of managing the financial resources for the Vaia emergency more directly, quickly and efficiently (Ordinanza n. 558, 15th Nov. 2018).

The combination of these institutional measures shows how the national government intended to favour an approach locally oriented, in order to better direct the investment plan for post-emergency works, because, in addition to the immediately visible damage to forests and infrastructures, other major risks such as landslides or flooding were also taken into account.

Finally, it is also interesting to note the bottom-up approach of the collaboration set in place between the many institutional and non-institutional bodies operating at the local level in the affected territories, which created a synergic framework for action with the regional commissioner's administration set up for the emergency.

Furthermore, another aspect that could additionally improve the institutional performance in managing windstorm effects over the affected territories is the valorisation and enhancement of the framework for action of local institutional bodies.

In the case of windstorm Gudrun in Sweden for example, the operational decisions promoted by the municipality of Ljungby, in light of their previous experience on-field acquired in the aftermath of Vivian windstorm in the 1990s, proved to be of enormous value in supporting the communities and other municipalities that remained "institutionally" isolated after the infrastructural devastation brought by Gudrun (Andersson et al., 2018). Specifically, Ljungby municipality decided to carry out rescue capillary operations to make sure every surrounding community had the electric power back after the storm struck, and then they started organising informative meetings for sharing their acquired experiences in recovery operations wherever and whenever needed, jointly with civic initiatives working voluntarily to carry out the clearing processes (Andersson et al., 2018).

Promoting this local-based approach between institutions and communities by providing on-hand technical support, is likely to tight up and enforce the network of trust between communities and the local institutional bodies, while increasing the communities' perception of institutional accountability, facilitating then the information sharing and collaboration. Indeed, every type of actor involved within the reconstruction process after windstorm Gudrun has directly benefited from such experience at the community's level, and this highlights even more the importance of recombining existing competencies into multiple local solutions which are then to be shared as useful good practices for future events.

Particularly, evidence from windstorm Gudrun’s case has also shown how spontaneously organized multi-skilled rural communities and local municipalities have been able to open to new cooperative working paths in a physical landscape that had completely changed after the disaster (Johannisson and Olaison, 2007; Andersson et al., 2018).
Overall, such aspects are very important within the improvement of institutional approaches regarding how to cope with windstorms’ effects: indeed, they show that a mix of mitigation and adaptation options implemented in a participatory and integrated manner can enable rapid and systemic action, which is necessary for an effective management of the local damages caused by extreme windstorms, especially for what concerns the more rural and geographically isolated areas.

5.3 COPING WITH THE ECONOMIC EFFECTS OF WINDSTORMS: BETWEEN GOOD PRACTICES AND MAJOR BOTTLENECKS

As a matter of fact, institutional responsiveness and accountability for the management of windstorm effects, largely relies also on the choice of methodological approaches and technical tools set in place to deal with such hazards, especially for what concerns the mitigation measures for managing the economic damages.
Considering that windstorms account for the second major climate threat in Europe, in terms of frequency, severity and economic impact, representing the 25% of European economic losses due to climatic hazards (EEA, 2017), it is more than clear that there is a need to design more comprehensive management strategies, including measures for prevention, damage estimation, and subsequently, adequate policies for the mitigation of the effects and vulnerability caused on the involved territories and communities.
With regard to damage estimation strategies, the example of windstorm Vaia showed an interesting combination of approaches.
After the destruction left behind by the storm, in addition to on-site assessments carried out by the operational teams with the support of drones and helicopters, also satellite mapping techniques were used with the help of Sentinel satellites and the Copernicus emergency system, which made it possible to obtain, within only five days, a valuable partial estimate of the damage inflicted by the storm on forests and the surrounding areas (Chirici et al., 2019).
Indeed, the time factor in such circumstances covers a fundamental role for having good results in the management of windstorms' effects at the local level: in fact, the sooner action is taken, the higher is the chance of avoiding other associated risks such as landslides or flooding, as well as limiting the degradation of felled timber and the associated phytosanitary risks (Chirici et al., 2019). Furthermore, the estimation of damages over the territories by means of satellite

mapping allows as well for the assessment of the damage extent also from the viewpoint of local biodiversity and landscape, offering a chance to rethink targeted strategies and plans for reforestation and environmental restoration that take into account also the evolutionary dynamics of the local natural context, as well as the features of forest sustainability and resilience (Lasen, 2019).

The aspect of estimating economic damage is very important because the more precise information related to the individual affected territories can be gathered, the more effective the economic support measures for the affected communities will be.

In this case, tools such as qualitative interviews with local communities could be useful supplementary means for the development of more locally-oriented recovery financial plans, as seen within the case of windstorm Gudrun in Sweden, where such qualitative tool proved to be an important approach for collecting data and opinions among the communities affected by the windstorm (Andersson et al.,2018).

On the other hand, with regard to the technical tools used to support recovery and reconstruction investments, as above mentioned, it is still not possible to detect a commonly shared approach, but still, some insightful operational approaches can be identified.

For example, within the forestry sector, when it comes to the economic effects of windstorms, the biggest threat is represented by the millions of cubic metres of windthrown timber (Caurla et al., 2015).

Along with causing infrastructural damage, isolating communities and increasing the risk of landslides or flooding, these incredible amounts of felled timber are always the focus of major debates on how they should be managed in order to have the least impactful way possible both economically and from the point of view of communities and the local environment.

Would it be better to leave the felled timber on the ground or to clean up the area? Would it be best to store it in warehouses or to export it? Should it be sold within the national market, or it would be better to open up to the international market? And overall, what could be the economic impacts of the different choices?

All these questions are actually representing the biggest common challenges that could be detected from all the windstorms' cases analysed.

When an extreme windstorm brings down up to four times the annual timber harvest, the economic picture to be faced is clearly very serious, especially for small and medium-sized enterprises within the affected territories, because when an extreme windstorm occurs, one of the major economic threats for the forestry sector, is the risk that windfall wood prices drop to zero, undermining the economic viability of local businesses (Caurla et al., 2015).

It is therefore essential to choose the appropriate management strategy, because a wrong choice may lead to a further economic loss to be added to the already critical damage toll.

For this reason, being equipped with appropriate technical tools for decisional support, together with an active involvement of local actors, could really make a difference in terms of the quality of the formulation of financial support plans.

Regarding decision support tools within this context, two interesting approaches can be brought up as positive examples from the literature review.

The first case concerns the management of windstorm Lothar in Switzerland, in which the process of economic recovery concerning the forestry sector has been organised and implemented by relying on the "Decision aid manual" released by Buwal in 2000, an operational document drafted according to the lessons-learned from another extreme windstorm, Vivian, which heavily affected Swiss in 1990.

The aim of such decisional-support tool was primarily helping out institutions and forestry professionals in reaching decisions as to which actions should be undertaken to manage the post-windstorm economic scenario, for example, whether fallen timber should be removed from a specific windthrow area or left, relying on the rationale of economic feasibility and human resources availability (Angst and Volz, 2002).

Such operational instrument, in addition to provide important background information as forest inventory data, included as well a section in which all observed damage can be reported, and by comparing previously acquired data, arguments can be then formulated for discussing whether to leave or harvest the fallen timber (Angst and Volz, 2002).

Specifically, the "Decision aid manual" was developed to assist forestry institutions and forestry professionals in the political and operational management of large-scale damage in mountain forests.

Within the case of windstorm Lothar, this decision-making tool was distributed among the administrations of the various affected cantons and such help was very welcomed as it provided great support in setting up locally oriented recovery plans, designed on the basis of local damaged and local economic needs (Angst and Volz, 2002).

What is not provided for in this type of manual, however, is the possibility of carrying out simulation scenarios over the medium and long-term depending on the type of economic decision and investment proposed.

The case of windstorm Klaus in France highlights precisely such operational limitation, namely the lack of impact assessment tools that provide for the possibility of carrying out simulations taking into account the interaction variables of the affected sector under consideration.

In the case of windstorm Klaus, which severely affected France in 2009, researchers Caurla and colleagues proposed an impact study on economic effects in 2015 to show how possible measures could be derived to mitigate local economic effects of windstorms in the forestry sector. Within their assessment, in order to understand the impacts of possible compensation strategies set in place in the aftermath of windstorm Klaus, the analytical approach was based on a bio-economic partial equilibrium model framework, namely the FFSM presented in section 4.3.1, thanks to which it was possible to carry out simulations of different scenarios by comparing the data from the governmental financial compensation plan with alternative plans, assuming alternative subsidies' distributions between storage and transport options (Caurla et al., 2015).

The advantage of using this type of model is that, since it is a model that includes highly specific data concerning local forests, it makes it possible to return an accurate simulation based precisely on the local situation of the territory under consideration.

This approach of comparing the negotiated recovery plan after windstorm Klaus with other possible scenarios provided helpful insights on how the different outputs would have affected the market and the many stakeholders operating within the recovering forestry sector (Caurla et al., 2015). In addition to the results of the model simulation, a worthwhile aspect of this analysis is the use of the above mentioned FFSM, as it could be an important contribution to innovation and improvement in windstorm damage management and adaptation strategies.

The results and simulations carried out thanks to a tool that takes into account the data of the territory and its specificities, certainly represents an interesting potential for the decision making process of the various stakeholders involved, as it can help, for example, windfall wood suppliers within the affected communities in the choice of exporting their windfall abroad, to other regions, storing it or even, it can support regional and local institutional bodies in the choice of the financial amount to invest for storage plans or transport plans in the aftermath of the windstorm.

Using a tool like this, with a potential for analysing the territory on a local level, could largely help in developing better-tailored impact assessments on the forestry sector and beyond as a whole, without neglecting territorial specificities as well, and could also complement and improve policy and institutional decision making on risk management and adaptation strategies.

6. WINDSTORMS' ECONOMIC EFFECTS AT THE LOCAL LEVEL: RESULTS AND OBSERVATIONS FROM THE CASE-STUDY OF WINDSTORM VAIA IN ITALY

With regard to the observations concerning the analysis of the possible effects of windstorm Vaia on the economic structure of the four regions examined by the study, it can be stated that the initial research hypothesis proves difficult to be verified.

As previously stated, when it comes to the analysis of windstorm's economic effects at the local level, one of the major bottlenecks is represented by the limited number and availability of in-depth studies carried out at the local level (Gardiner et al., 2013).

In fact, at the general level, no significant data can be taken to demonstrate with confidence a direct cause-effect relationship between windstorm Vaia in Italy and the birth-mortality trend of the regional and provincial businesses performances taken into account.

In light of the high number of data and graphs obtained, the study's results have been displayed within the Annex section, ordered according to the regional and provincial analysis.

Then, for what concerns the general considerations over the obtained results, by observing the sectoral comparison graphs between the four regions, the assumed pre- and post-storm sectoral scenarios resulted not being in line with the research hypothesis.

As repeatedly emphasised, the forestry sector and the activities closely dependent on it, represent the most exposed and most affected by windstorm damage (EEA, 2017).

Consequently, a decrease within the activity rates in these sectors was expected in the results, as well as an increase in the activity rates of the sectors most involved in the post-storm phases, such as the construction one, but instead, this descriptive statistics approach did not allow for these trends to be highlighted or refuted.

Specifically, sectors of primary importance such as forestry or agriculture and animal products sectors, showed a linear evolution and did not present negative or positive peaks as initially assumed, as well as the construction sector, for which a strongly positive trend was hypothesised, assuming an increase in demand for clearing and reconstruction operations, especially in the most affected provinces.

Probably, in addition to the type of statistical approach, another influencing feature on such result, which should also be considered on a general level, is the time range selected for the data search.

If a broader time series had been taken into consideration, the chances of verifying or refuting the predicted trends would probably have increased, but this was not possible in light of the fact that data on the subject are lacking (Caurla et al.,2015) and are generally fragmentary,

discontinuous and not homogeneous. Consequently, it was not possible to use them with confidence to create the statistical study, effectively placing an operational limitation on it.
In addition, another important aspect to be taken into consideration is that there are currently no studies and statistical research in the literature that explore this research topic in depth, especially with a focus on a local scale, and therefore the lack of references does not allow the hypothesis and results found to be associated with other empirical evidences.
Despite these premises, it was nevertheless possible to draw some interesting observations from the data examined.
An interesting trend, is observed within the regional sectoral comparison concerning energy supply services (fig.19): indeed, during the three-year period 2017/2019 considered, a sudden drop within this type of services was found in the Trentino Alto Adige region compared to the other regions studied, presenting a 5.4% higher percentage of ceased activities in the post-Vaia period (2019) compared to the previous ceasing rates of 2.4% in 2017 and 2.2% in 2018.

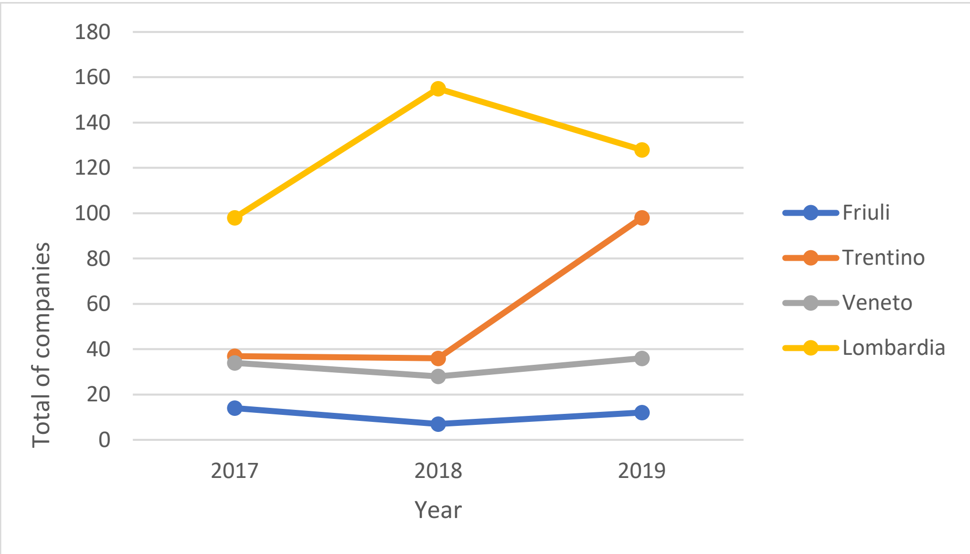


Fig.19 *Regional comparison of Vaia's affected regions showing the ceasing trend of the companies within the energy supply services sector. Source: own elaboration based on Movimprese database*

With regard to the analysis carried out at the level of provinces, although the observed data reflects the absence of causality between economic trends and the Vaia storm as already seen within the regional comparisons, there are still a few cases in the sectoral performance of specific provinces that could, however, constitute an interesting object of in-depth study or research cue for further statistical study, namely:
- within the construction sector of Friuli region, in the province of Gorizia, an important decrease in active enterprises was observed in 2019, as shown in *fig.20 and 21*, which went from having an activity rate of 90.8% in 2017 and 89.3% in 2018, to one of 86.5% in 2019,

presenting respectively a percentage of ceased activities of 9.2% in 2017 and 10.7% in 2018, to a 13.5% in 2019;

- in the catering sector in Friuli region, in the province of Trieste, a drop in active businesses was observed in 2019, as shown in *fig.22 and 23,* starting from having an activity rate of 92.4% in 2017 and 93.4% in 2018, to a 90.7% in 2019, presenting respectively a percentage of ceased activities of 7.6% in 2017, 6.6% in 2018 and 9.3% in 2019

- within the energy supply services sector of Trentino Alto Adige region, in the province of Trento, an important decrease in active companies was observed in 2019, which went from having an activity rate of 95.7% in 2017 and 93.9% in 2018, to one of 84.4% in 2019, presenting respectively a percentage of ceased activities of 4.3% in 2017, 6.1% in 2018 and 84.4% in 2019, as illustrated by *fig.24 and 25;*

- within the accommodation sector of Veneto region, in the province of Belluno, an important drop in active businesses was observed in 2018, from a percentage of activity of 96.7% in 2017 to one of 90.8% in 2018, which then rose again to one of 97% in 2019, presenting respectively a percentage of ceased activities of 3.3% in 2017, 9.2% in 2018 and 3% in 2019, as *fig. 26 and 27* illustrates.

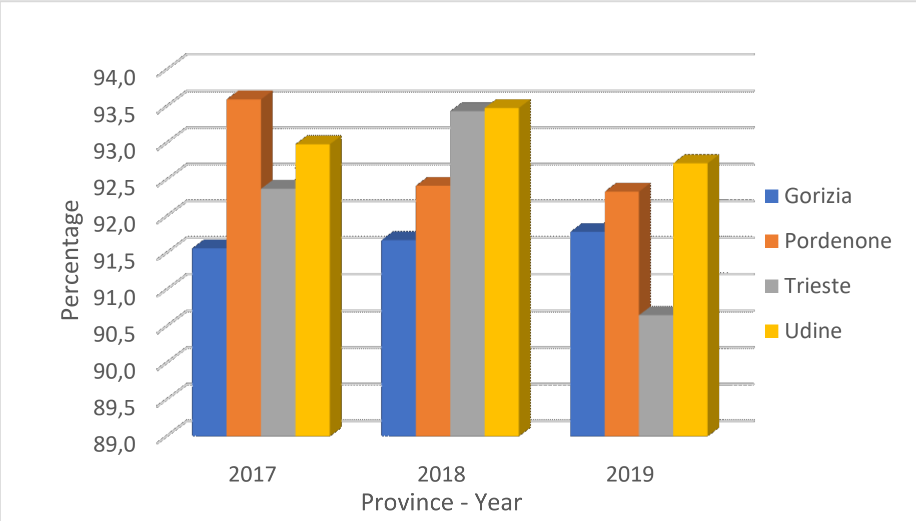


Fig.20 *Friuli Region: Percentage distribution of active enterprises over the total, in the construction sector*
Source: own elaboration based on Movimprese database

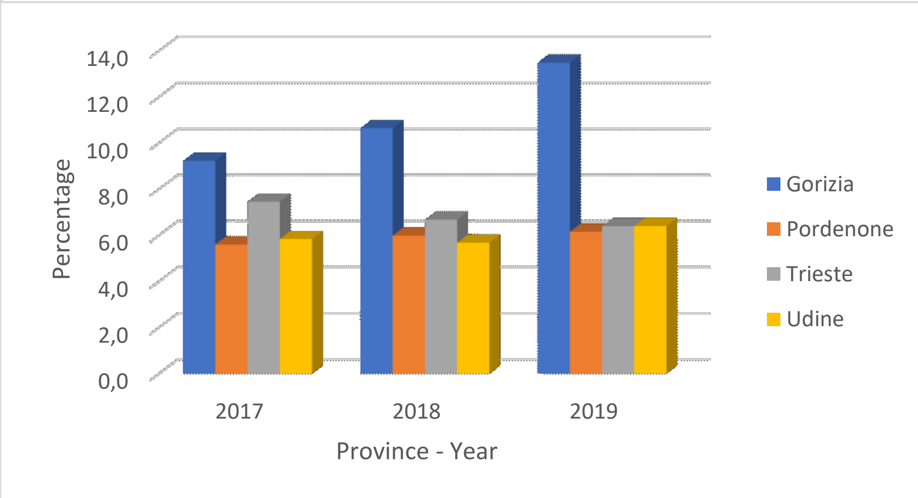


Fig. 21 *Friuli Region: Percentage distribution of ceased enterprises over the total, in the construction sector*
Source: own elaboration based on Movimprese database

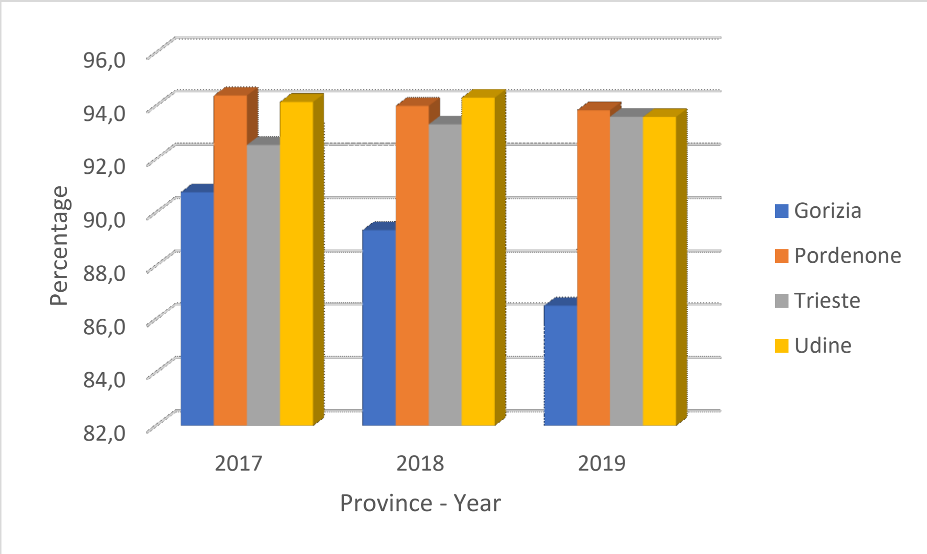


Fig.22 *Friuli Region: Percentage distribution of active enterprises over the total, in the catering sector Source: own elaboration based on Movimprese database*

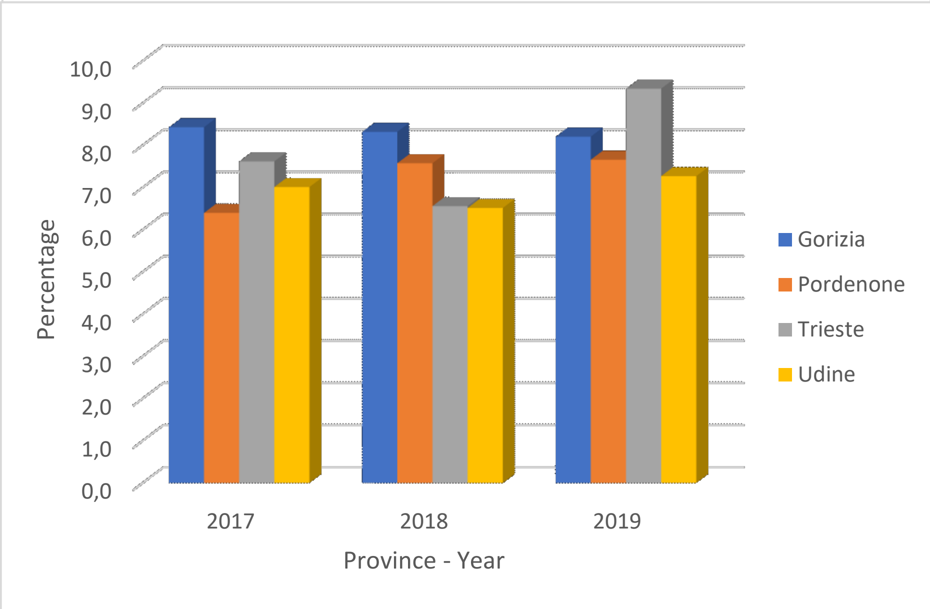


Fig. 23 *Friuli Region: Percentage distribution of ceased enterprises over the total, in the catering sector Source: own elaboration based on Movimprese database*

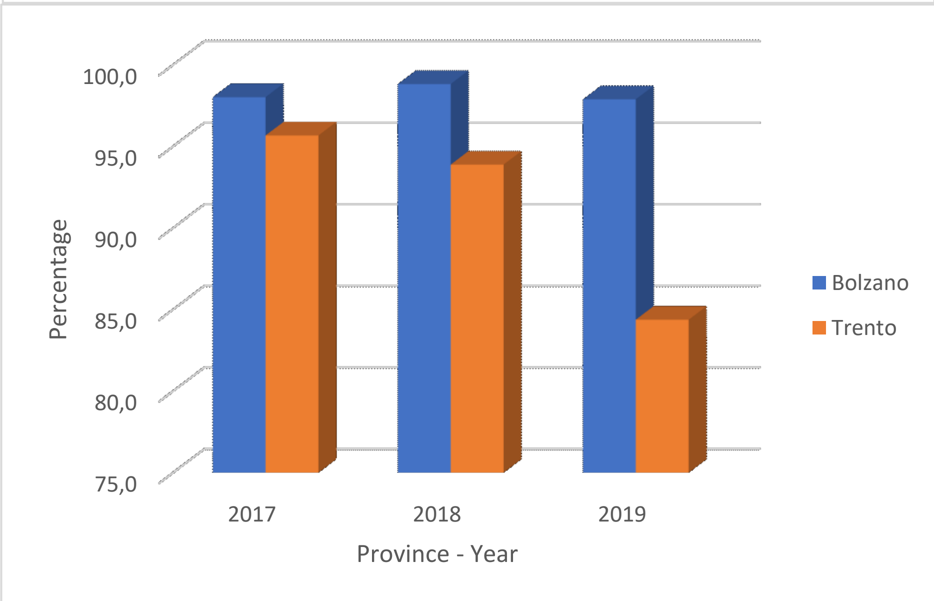


Fig.24 *Trentino A.A. Region: Percentage distribution of active enterprises over the total, in the energy supply services sector Source: own elaboration based on Movimprese database*

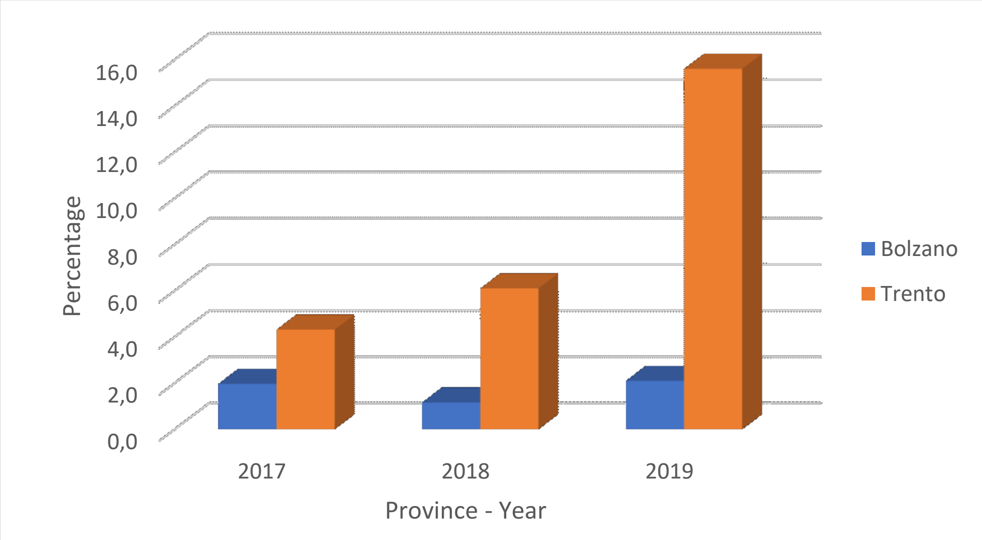


Fig.25 *Trentino A.A. Region: Percentage distribution of ceased enterprises over the total, in the energy supply services sector*
Source: own elaboration based on Movimprese database

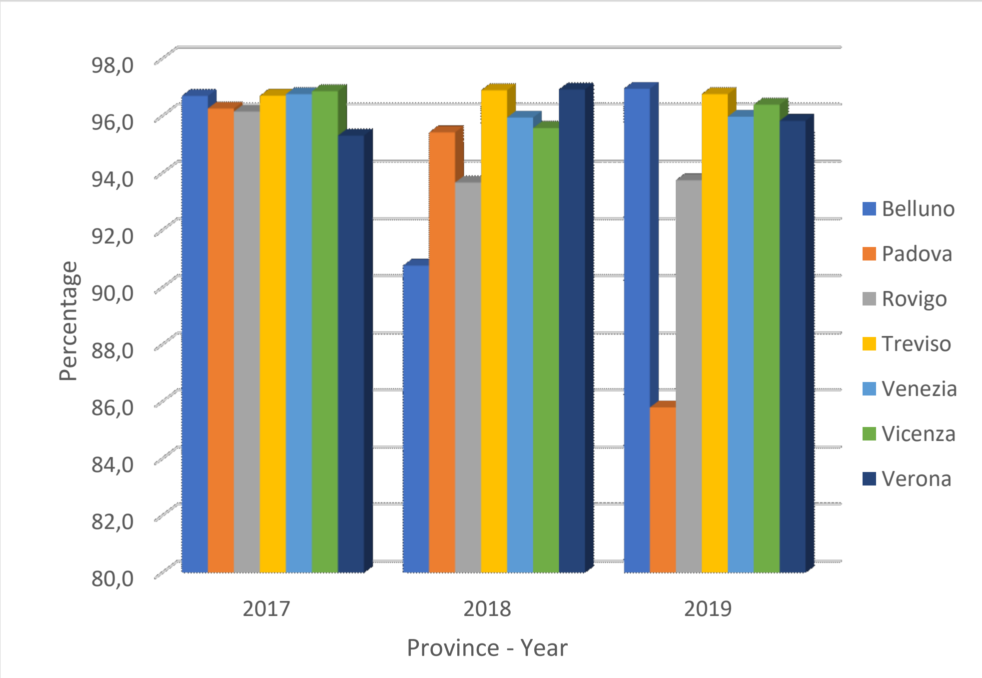


Fig.26 *Veneto Region: Percentage distribution of active enterprises over the total, in the accommodations sector*
Source: own elaboration based on Movimprese database

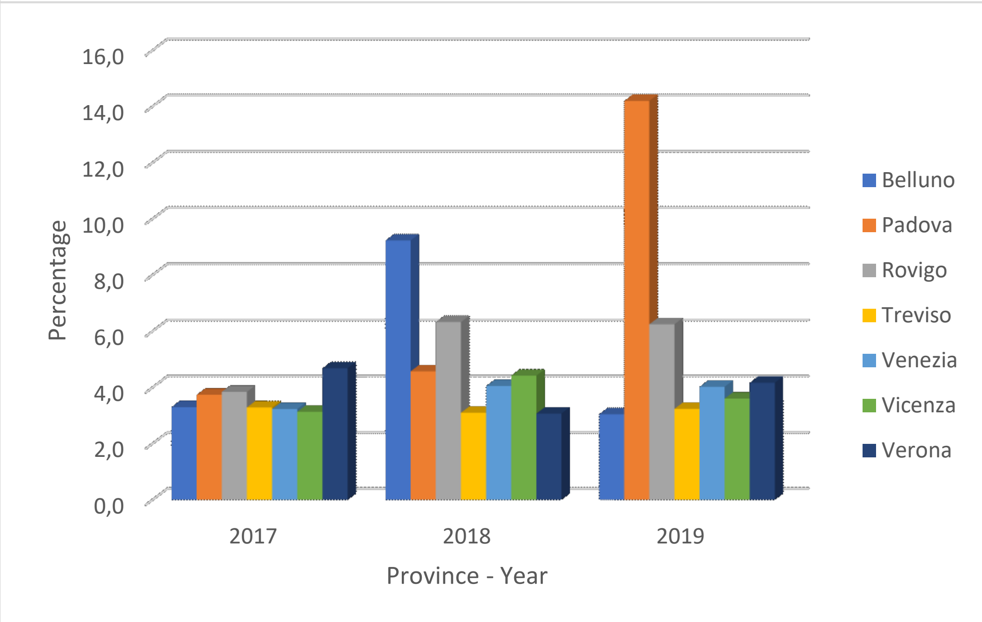


Fig.27 *Veneto Region: Percentage distribution of ceased enterprises over the total, in the accommodations sector*
Source: own elaboration based on Movimprese databases

7. RESEARCH LIMITATIONS

7.1 OF THE LITERATURE REVIEW

As stated within the introductory section, the present work aimed at focusing on the consequences of extreme windstorms in Europe, drawing the attention especially towards the analysis of their effects on the local natural and human systems, jointly with the goal of finding out how they are managed at the institutional, economic and societal level.

At the general level, the biggest obstacle encountered within this research is that the subject of study, extreme windstorms in Europe, is a rather recent topic considering that the scientific community begun to deal with it in depth only around the 1990s (Berz, 2005).

Therefore, most of the resources made available within the literature are rather sectoral and more oriented towards a highly technical-scientific investigation.

Specifically, the majority of the available literature concerns studies of European windstorms in the field of climatology and forestry.

Much of the information is focused on the study of climate models of windstorms or their effect on forests and the resulting consequences on biodiversity, forestry or economic activities closely related to the forestry sector.

Consequently, a second obstacle noted, given the high sectoral and rather technical nature of the material, was the relatively limited number of in-depth studies more oriented towards the social field, e.g. how the effects of storms affect the exposure and vulnerability of concerned communities, and to the institutional aspects e.g. if and how windstorms effects could change the way decision making processes are structured

Another major bottleneck is represented by the fact that in general, the variety of data related to the effects of windstorms in Europe is usually not complete, nor harmonised, since a common monitoring system for data related to national hazards is not yet in place for the European area, making it very difficult to find comparable data and being able to derive a quantitative analysis. (Gardiner et al., 2013).

Thus, unfortunately, in some cases it was just not possible to gather useful complementary information, as it is for the case – for example – of data related on how many thousands of people were affected in total for the different case studies of windstorms taken into account.

Therefore, these research limitations meant that the present work focused mainly on the study of literature on windstorms and their effects within the forestry dimension and its closely related sectors, as such broad field has been reported as the most affected one in relation to this kind of natural hazard (Gardiner et al., 2013). So, despite in general there is a limited number of studies carried out within the social, economic and institutional field of windstorms effects, it was nevertheless possible to find out some very interesting literature work which made it possible to create a comprehensive and locally focused body of case studies.

7.2 OF THE STATISTICAL STUDY

Although on one hand this descriptive statistical study did not reveal any clear causal relationships, on the other it allowed for a more detailed understanding of the operational limitations of an analysis carried out within the local and regional context.

In the first place, the greatest difficulties were encountered above all during the phase of data gathering: in fact, the many sources consulted often reported partial data, obsolete data, or in other cases, it was not made explicit how the data of interest was obtained.

Consequently, this aspect further highlights the need to process data in a harmonised manner, and above all, to update the information availability.

In fact, the factor of clarity and functionality within the availability and representation of data represents a crucial feature for an improvement of statistical analyses, especially for what concerns future studies at the local level.

For example, starting with this study on the birth-mortality variable of enterprises, such analysis could be taken to a more detailed level of accuracy through the inclusion of other types of economic variables, such as, for example, the trend in turnovers.

In conclusion, despite this study carries methodological limitations at the general level as it is a descriptive and not an inferential statistics analysis, and also operational, considering the difficult availability of harmonised data at the local level, it can nevertheless represent a good starting point for improving future further research.

8. CONCLUSIONS AND FUTURE PERSPECTIVES

Despite the fact that the European scientific community begun to study in depth extreme windstorms only within the last twenty years, a general observation that can be stated with confidence is that the evolutional future of windstorms in Europe proves difficult to predict, especially in terms of their intensity and frequency, and consequently, so are their potential effects on societies, institutions and economies (IPCC 2012; Roberts et al, 2014; EEA, 2017).

From a general theoretical point of view, this work has shown that there is a broad and sound theoretical methodology dealing with windstorm risk management and risk mitigation strategies (e.g. Riguelle et al. 2016). However, when turning to the analysis of the operational level, in most of the local contexts examined within the selected four case studies of extreme windstorms in Europe, the management approaches have shown to be anything but linear with respect to the methodology of the adopted strategies.

Indeed, and as expected, what emerged from this work is a complex picture of interactions and multi-level interdependence between the social, economic and institutional components taken into consideration: in fact, such case studies made it possible to highlight the greatest potential present within the different territorial contexts, as well as the greatest challenges and limits to action, and also, they allowed for a close investigation on the territorial roles covered by these features in managing windstorms effects.

For example, one of the most meaningful findings showed how the social component, which at the theoretical level is pointed out as the most exposed dimension to the risk of vulnerability and fragility, could represent at the same time also a key-source for local innovation within the territorial management of windstorms effects (Johannisson and Olaison, 2007; Andersson et al., 2018).

Or also, the strategic importance of the local collaborative networks that can be created in the aftermath of the extreme windstorm: indeed, when such violent event occurs, the local institutional, social and economic routine is being inevitably disrupted.

It can be observed then, how distinction between local institutions, businesses or fellow citizens fades away within such circumstances, allowing the creation of collaborative connections within different formal and informal structures, enforcing potential entrepreneurial initiatives and the consequent release of hidden social capital in the face of disaster.

Evidence from the analysis also highlighted how such social networks within the local dimension are capable of influencing whether and how individuals seek risk-related information and also how they process it in coping with the territorial effects of windstorm events (Johannisson and Olaison, 2007; Andersson et al., 2018).

Therefore, the perceived effects of such climate extremes within the local context can be identified at an individual but also at a community level, as seen in particular within the local cases dealing with the forestry sector, as it is recognized as one of the most vulnerable domains within the management of windstorms effects since it covers a vital economic and social role, especially in rural areas.

These observations within the social sphere represents a major opportunity for future policy improvement, because in a general policy context which is mainly driven from a management approach that is profit-oriented and path-dependent, the integration of the social variable within the decision-making processes would represent an important source of innovation for the future in the management of this type of extreme climatic hazards.

Thus, while the work offers an alternative viewpoint of some elements that constitute a potential strategic feature for territories in the context of responding to the effects of windstorms, it also highlights the major obstacles within such systems.

Indeed, from the case studies analysed, it can be inferred that there are still no shared operative models for managing this type of climate extreme events: what emerged from the many local contexts analysed is that management techniques and recovery policies vary locally, according to the institutional, social and economic capacities and the strength of their territorial trust bonds.

For this reason, being aware of territorial specificities is fundamental, as they are the result of the long process of adaptation between the human system and the natural system, each of which bringing different historical, cultural and socio-economic identities that are central to local development (Trigilia, 2001).

Therefore, the way in which each local dimension is known and interpreted is fundamental in a perspective of territorial development and improvement of windstorm management strategies, because the solutions to territorial problems formulated at a global level could be certainly more effective if declined at the practical level according to the local context and its respective characteristics (Garofoli, 2002).

Among the positive aspects of including territorial specificity in policy-making processes, it is important to emphasise the opportunity to formulate place-based approaches and solutions that are locally relevant. On the other hand, however, one of the major limitations of this aspect becomes visible, namely the difficulty in extracting and exporting the local virtuous mechanisms known as “lessons to learn” elsewhere, and this is mainly due to the territorial specificity and the difficulty of repurposing them within other contexts (Trigilia, 2001).

An example of such difficulties could be the above-mentioned considerations on the importance of social capital: although this may be a lesson valid everywhere, it is then challenging on a

practical level to give indications on how this social capital could be consolidated in different contexts, if not with general indications on how to reinforce local networks, because each local context is unique, especially at the level of cultural and social identity.
Certainly, the implementation of a commonly shared and local oriented windstorm management model would represent a desirable future scenario, but such potential progress is strongly dependant also on another major limitation encountered, namely the lack of harmonised data, and the limited availability of locally based studies (Caurla et al., 2015).
In particular, the lack of sharable data and information may be responsible for slowing down the progress of strategy design at the local level, indirectly limiting the process of improvement in the management of windstorm effects, as the exchange of good practices is undermined by the lack of commonly shared operational methodologies. This aspect has proved being particularly important within the data research phase concerning the case study of windstorm Vaia in Italy, during which it was complicated to find locally harmonised economic data, as of all those examined, there was only one suitable dataset capable of providing complete and comparable data with a regional and provincial focus.
Consequently, the statistical study was unable to determine the extent to which Storm Vaia affected the trend of business openings and closures in the affected territories, further underlining how important it is that monitoring systems functional to an impact assessment must be created and regularly updated with reliable data. Despite these major methodological and operational hurdles, it was nevertheless possible to also identify several positive elements, which could certainly represent a major turning point for improving and strengthening windstorm management in the future. In particular, what sharply emerged, and which represents one of the most relevant potential factors for positive change, is precisely the local dimension of the analysis itself.
Reframing the analytical focus starting from the territories, formulating institutional approaches that are locally-oriented and favouring an inclusive, bottom-up, participatory and multidisciplinary dimension of dialogue.
Several times in the course of this analysis, it has been emphasised how the local resources inherent in the social capital of communities represent an enormous potential immaterial wealth. An asset capable of creating valuable synergic connections by intertwining with the local institutional dimension, ensuring trust networks among local communities and institutional bodies and improving information-sharing processes thanks to the territorial local knowledge and local know-how.
Undeniably, the aspect of communication between these dimensions constitutes an essential element for a future perspective in which the greater level of cohesion between the knowledge

of territorial contexts and the design of risk management policies aims at favouring more and more locally-oriented approaches aware of the specificities of territories.

In fact, for the management of the effects of windstorms, social and institutional synergies have proven to be fundamental features within the framework of risk-reduction policies: they are both focused on diminishing exposure and vulnerability and at the same time, they are oriented towards an increase of socioeconomic resilience to the potential adverse impacts of windstorms effects, allowing an improvement within the capacity of societies and communities to prepare for and respond to future disasters, even though risks cannot fully be eliminated.

Indeed, as emerged from the literature review, the set of all these multi-layered and intertwined dynamics lead the way for a further highlighting of the key-role played by the local dimension as core starting point for rethinking the social, institutional and economic systems to be set in place for coping more efficiently with windstorms events and their unpredictable effects.

Also, regarding the institutional aspects, it would be a strategic decision to create capacity-building programmes, especially turned to local public administrations, as they still represent the reference actor within the territorial level for post- climate emergencies action plans.

Indeed, despite the existence of previous similar experiences in other countries, to date this type of local actor still struggles to act in the face of the emergency with promptness and effectiveness, especially with regard to the formulation of long-term strategies aimed at prevention and mitigation of windstorms effects.

In addition, as shown by the analysis of the economic data concerning the Italian regions affected by windstorm Vaia, a further limiting factor on institutional capacities for local action is the lack of suitable statistical data to detect the effects of extreme climatic events such as these, which are fundamental for providing valuable decision-support tools to local public administrations and policy makers.

In conclusion, it can be assessed that future improvements on setting up windstorms' risk prevention and mitigation frameworks for action should proceed by adopting a multidisciplinary and local-aware approach that might need as well to focus on the level to which the many socio-economic features such as, local experience and local networks may influence perceptions of risk, and therefore, enforcing or hindering decision-making processes and the resulting policy framework as well as encouraging the improvement of data collections and updating at local level.

However, the effects of windstorms and their future evolution may never be predicted with certainty, and consequently, the risks associated with them will never be completely eliminated.

For this reason, it is essential to encourage the stakeholders' active involvement within decision-making processes, while trying to build up a more cohesive local, regional and national framework for action in order to better identify which are the key socio-economic, political and environmental drivers that may influence and positively enforce future management choices.

ANNEX

A. Regional trend comparisons charts of primary, secondary and tertiary sectors

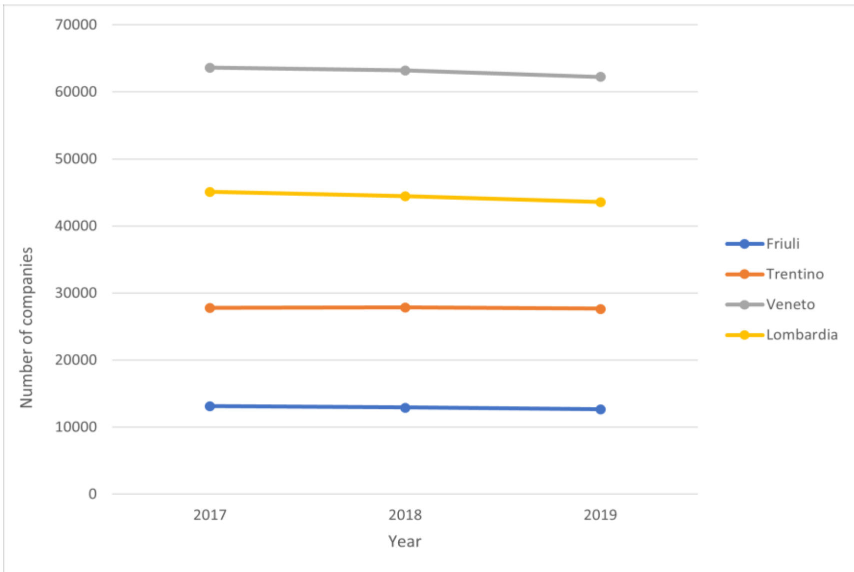


Chart 1. Regional comparison: *trend in the number of active enterprises in the agriculture and animal products sector. Source: own elaboration based on Movimprese database*

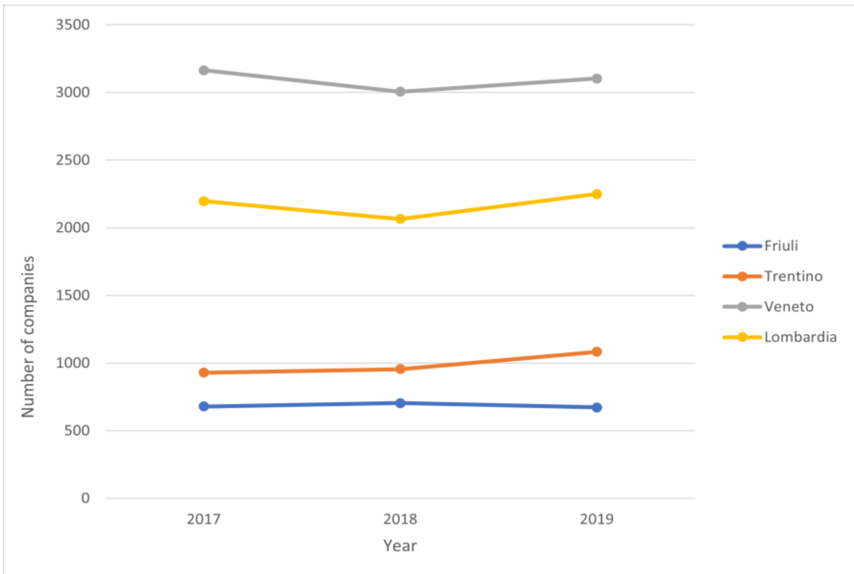


Chart 2. Regional comparison: *trend in the number of ceased enterprises in the agriculture and animal products sector. Source: own elaboration based on Movimprese database*

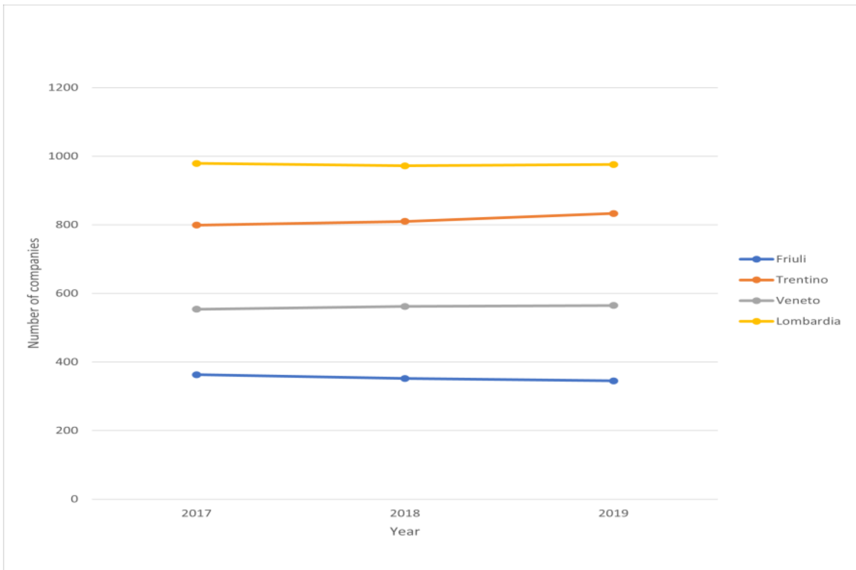


Chart 3. Regional comparison: *trend in the number of active enterprises in the sector of forestry and use of forest areas. Source: own elaboration based on Movimprese database*

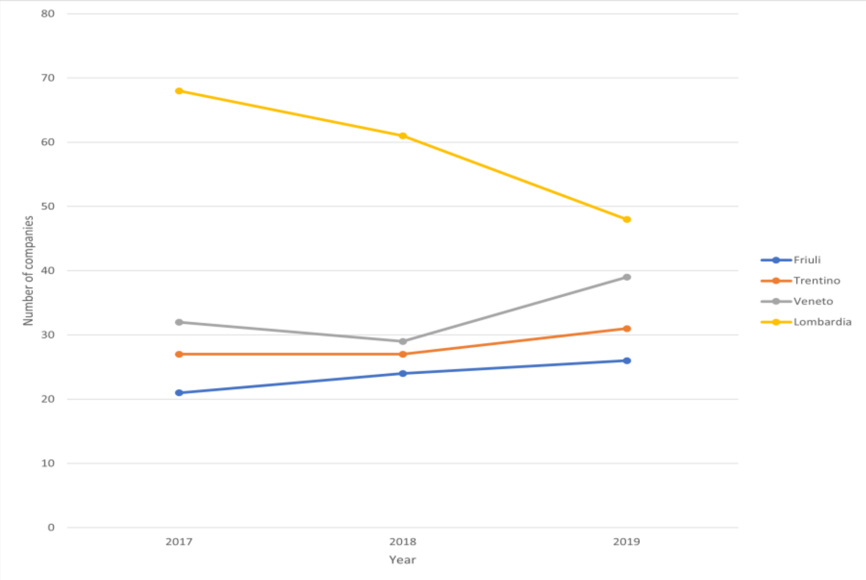


Chart 4. Regional comparison: *trend in the number of ceased enterprises in the sector of forestry and use of forest areas. Source: own elaboration based on Movimprese database*

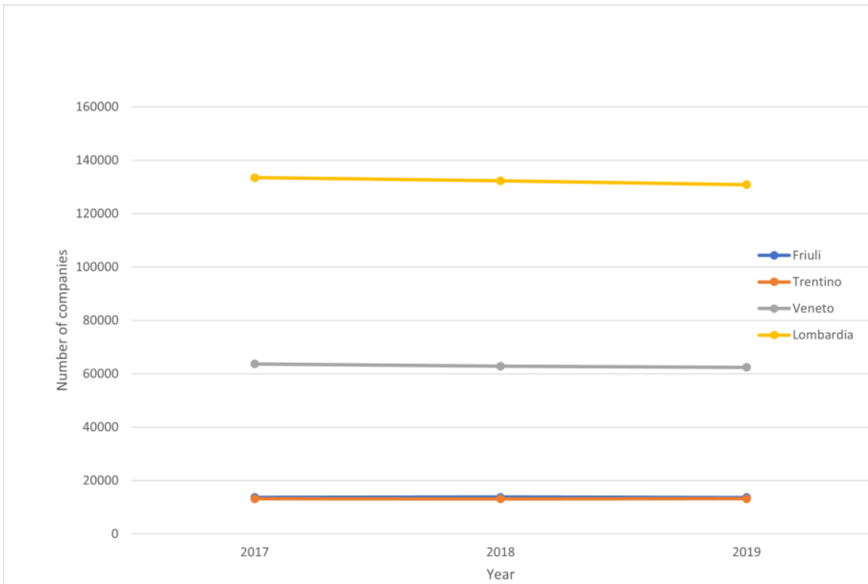


Chart 5. Regional comparison: *trend in the number of active enterprises in the sector of constructions. Source: own elaboration based on Movimprese database*

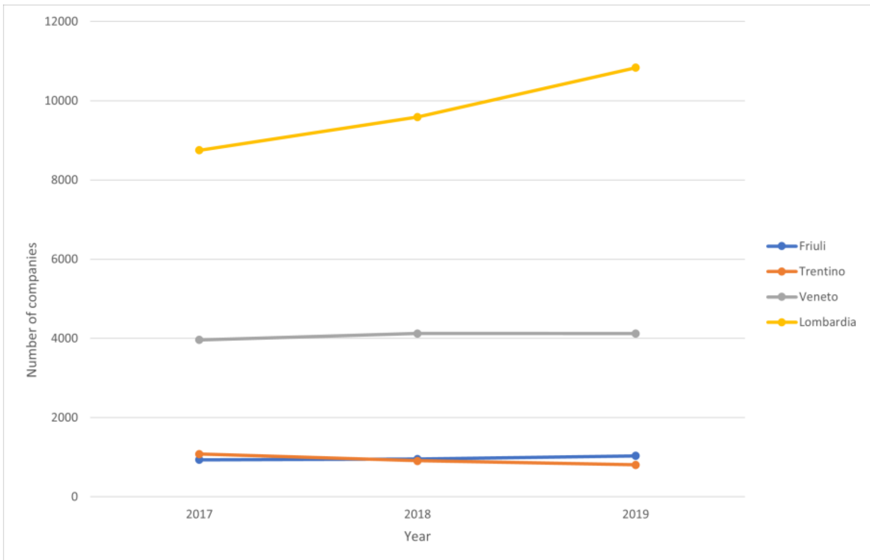


Chart 6. Regional comparison: *trend in the number of ceased enterprises in the sector of constructions. Source: own elaboration based on Movimprese database*

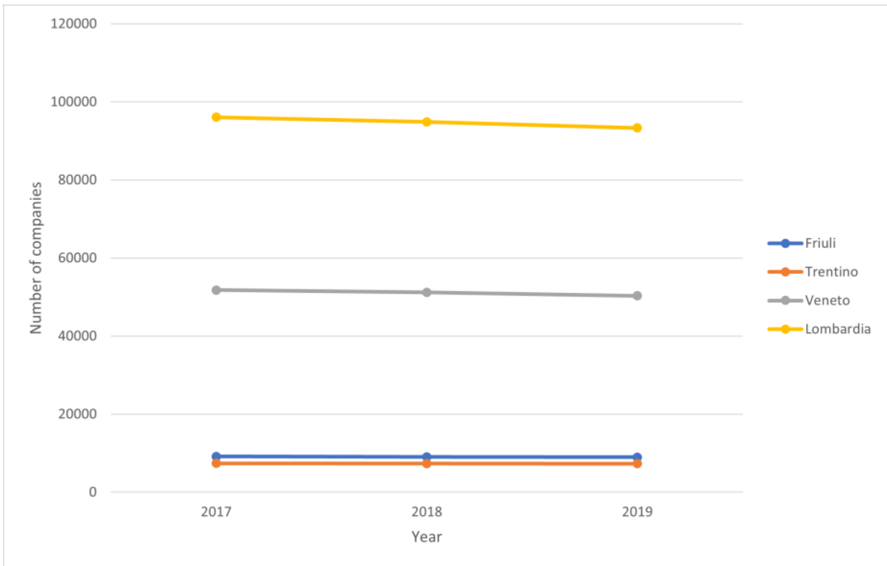


Chart 7. Regional comparison: *trend in the number of active enterprises in the sector of manufacture. Source: own elaboration based on Movimprese database*

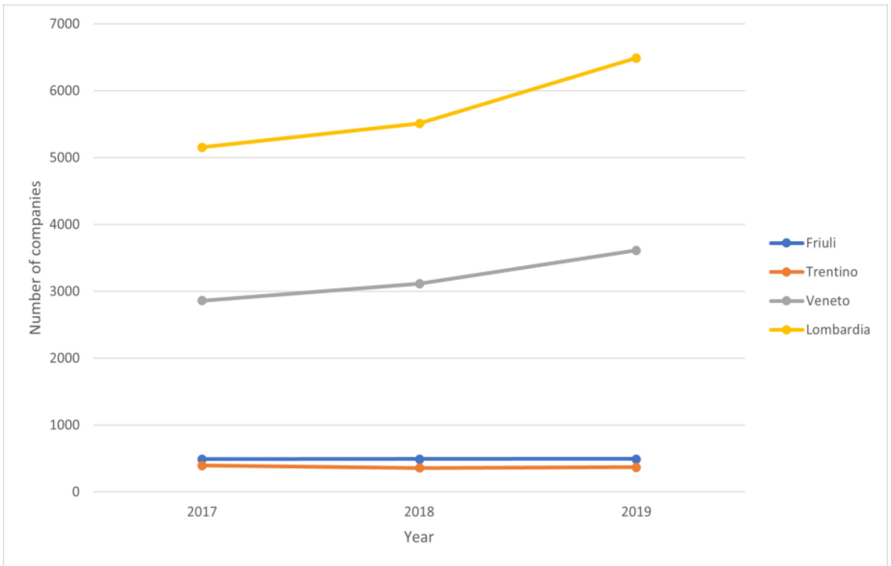


Chart 8. Regional comparison: *trend in the number of ceased enterprises in the sector of manufacture. Source: own elaboration based on Movimprese database*

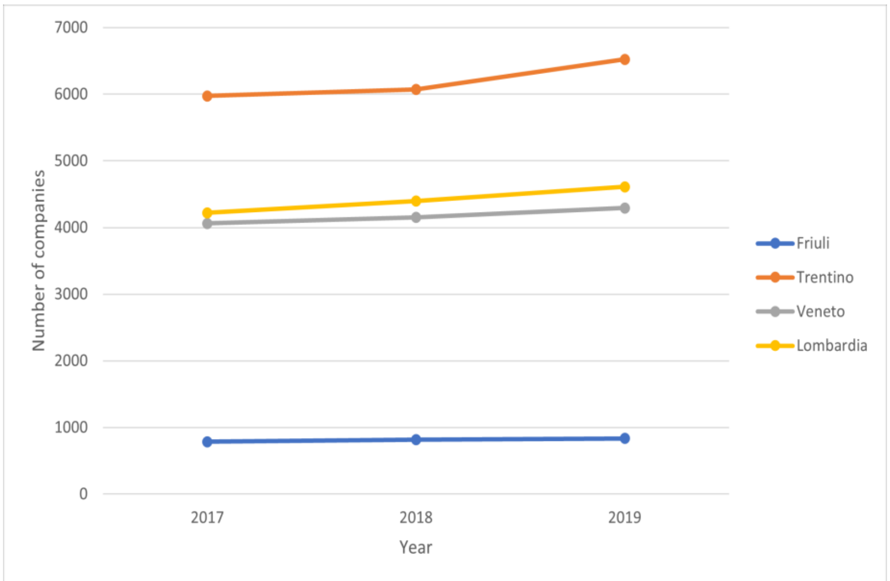


Chart 9. Regional comparison: *trend in the number of active enterprises in the sector of accommodations. Source: own elaboration based on Movimprese database*

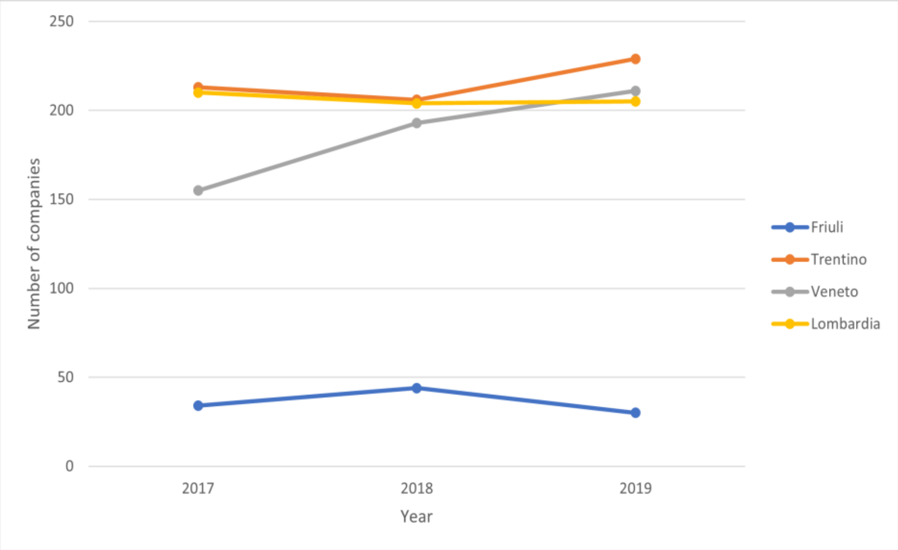


Chart 10. Regional comparison: *trend in the number of ceased enterprises in the sector of accommodations. Source: own elaboration based on Movimprese database*

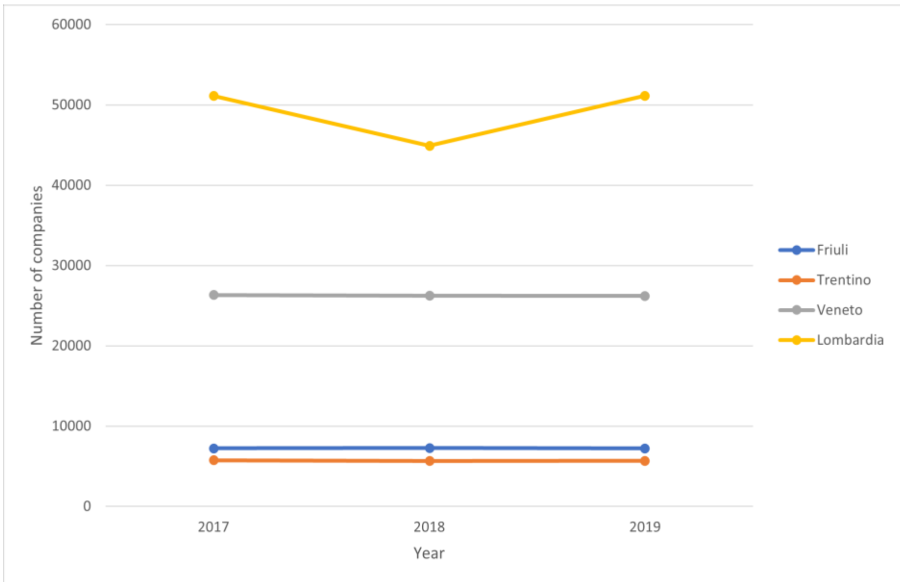


Chart 11. Regional comparison: *trend in the number of active enterprises in the sector of catering. Source: own elaboration based on Movimprese database*

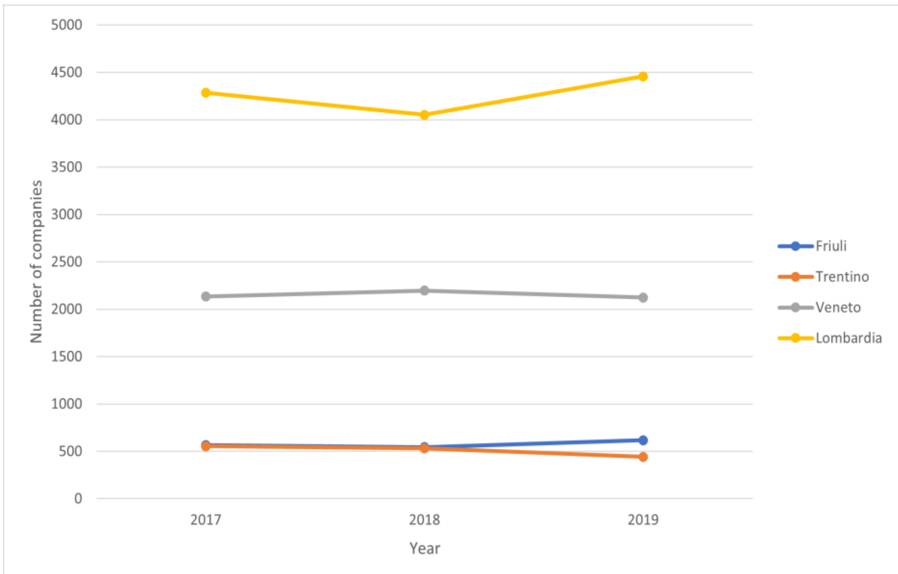


Chart 12. Regional comparison: *trend in the number of ceased enterprises in the sector of catering. Source: own elaboration based on Movimprese database*

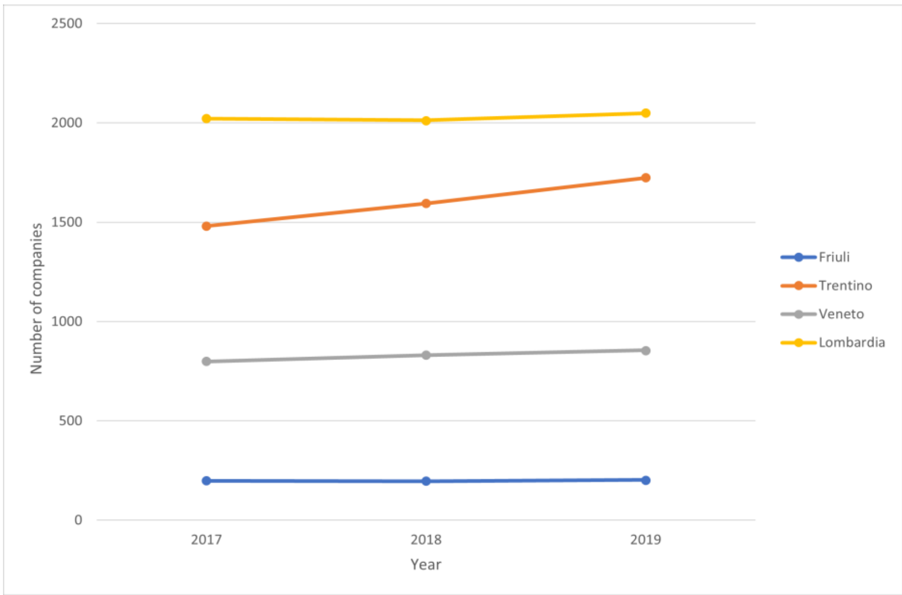


Chart 13. Regional comparison: *trend in the number of active enterprises in the sector of energy supply services. Source: own elaboration based on Movimprese database*

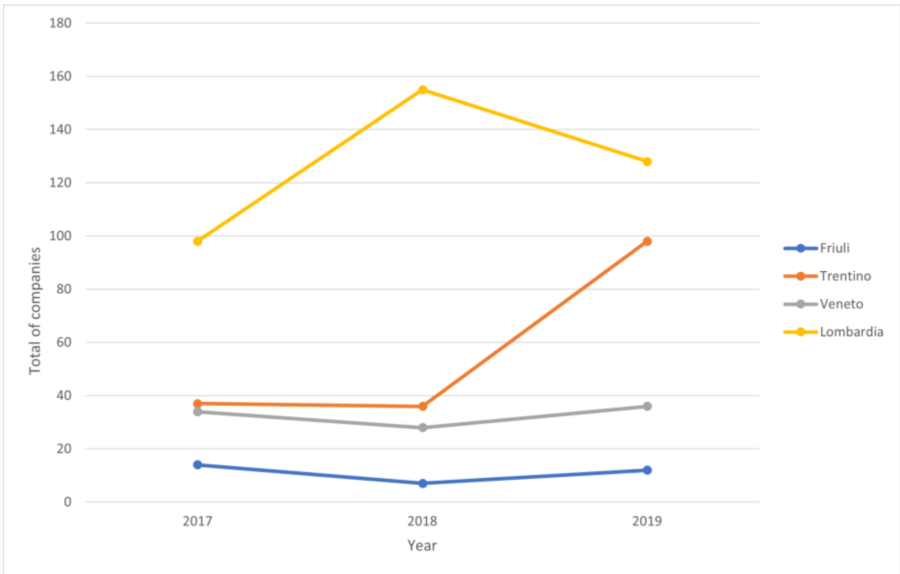


Chart 14. Regional comparison: *trend in the number of ceased enterprises in the sector of energy supply services. Source: own elaboration based on Movimprese database*

B. Provincial trend comparisons charts of primary sectors

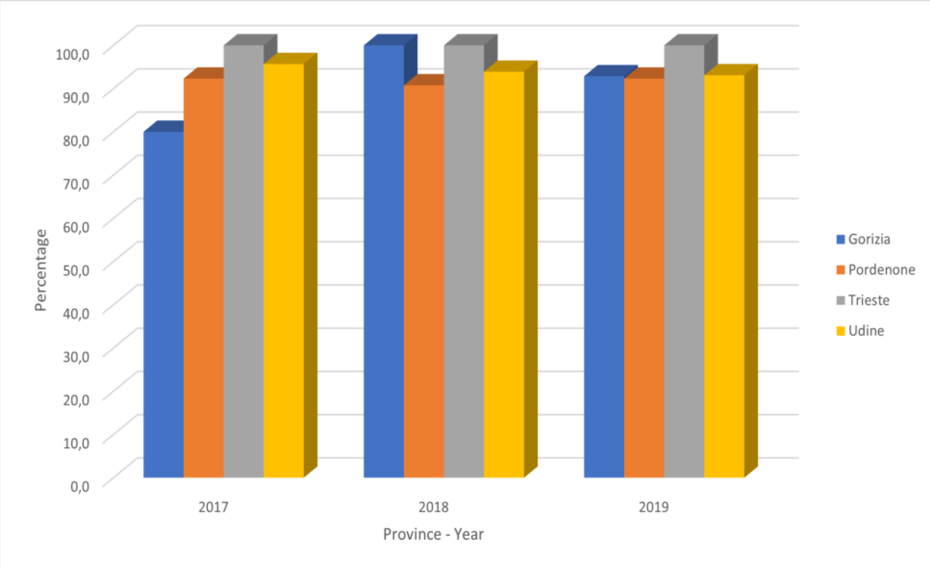


Chart 15. *Friuli Region: Percentage distribution of active enterprises over the total, in the sector of silviculture and use of forestry areas. Source: own elaboration based on Movimprese database*

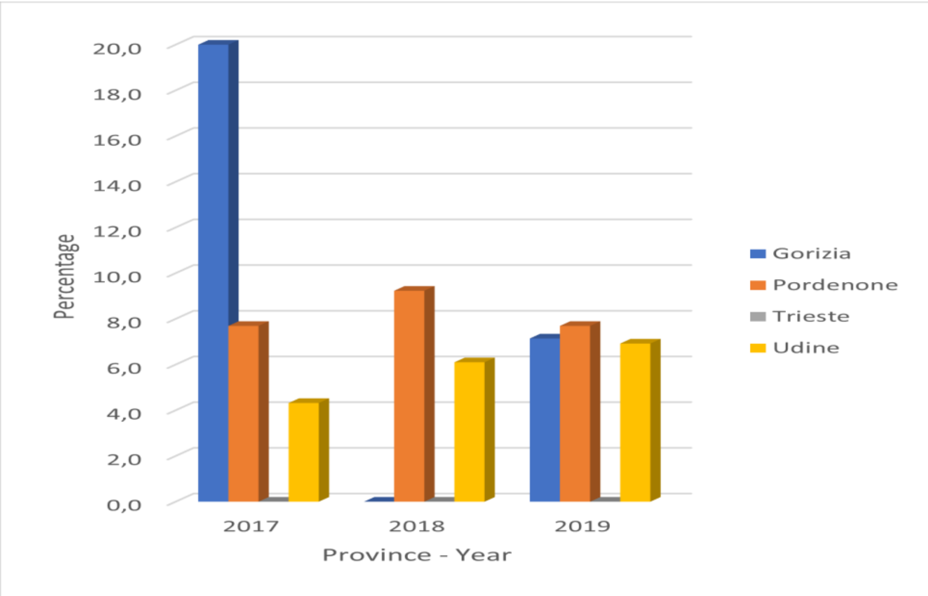


Chart 16. *Friuli Region: Percentage distribution of ceased enterprises over the total, in the sector of silviculture and use of forestry areas. Source: own elaboration based on Movimprese database*

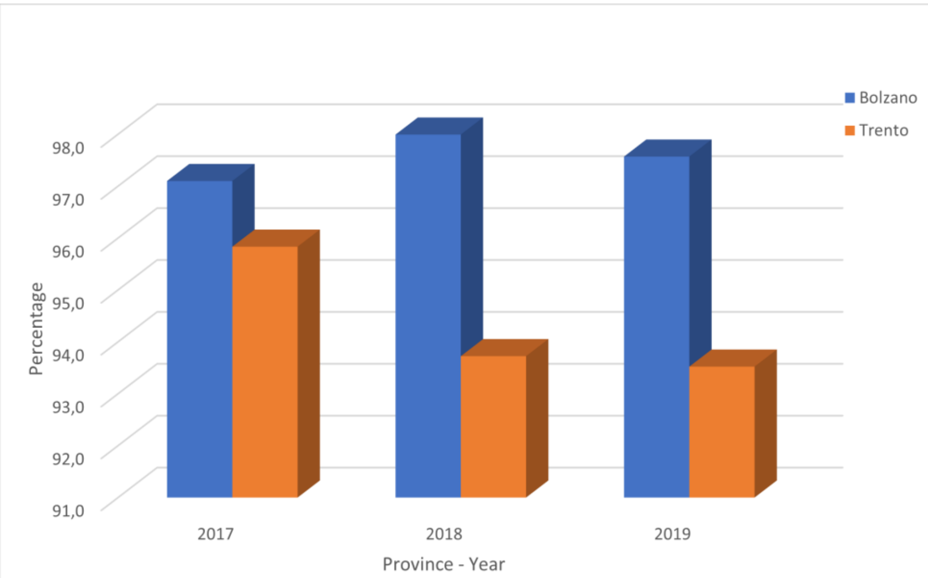


Chart 17. *Trentino A.A. Region: Percentage distribution of active enterprises over the total, in the sector of silviculture and use of forestry areas. Source: own elaboration based on Movimprese database*

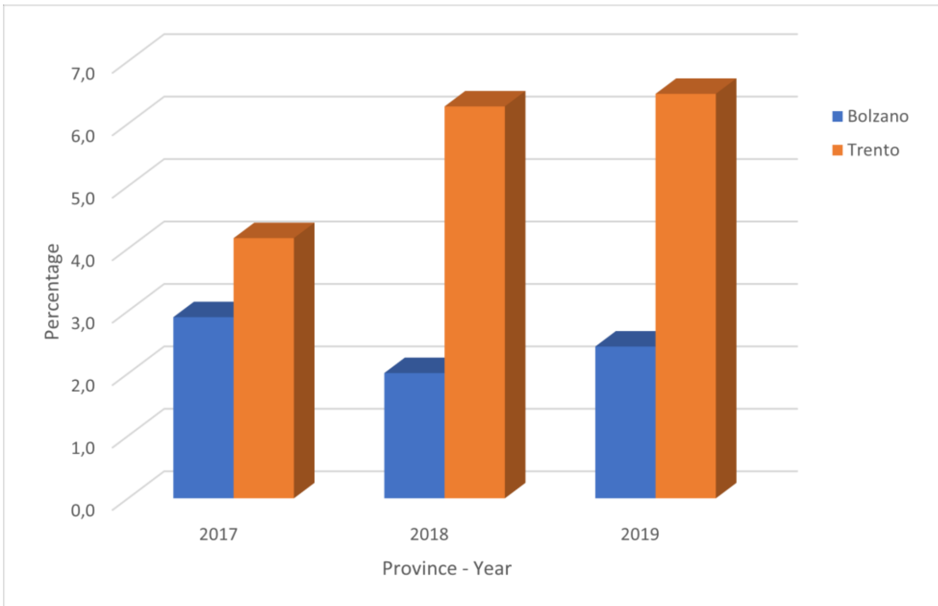


Chart 18. *Trentino A.A. Region: Percentage distribution of ceased enterprises over the total, in the sector of silviculture and use of forestry areas. Source: own elaboration based on Movimprese database*

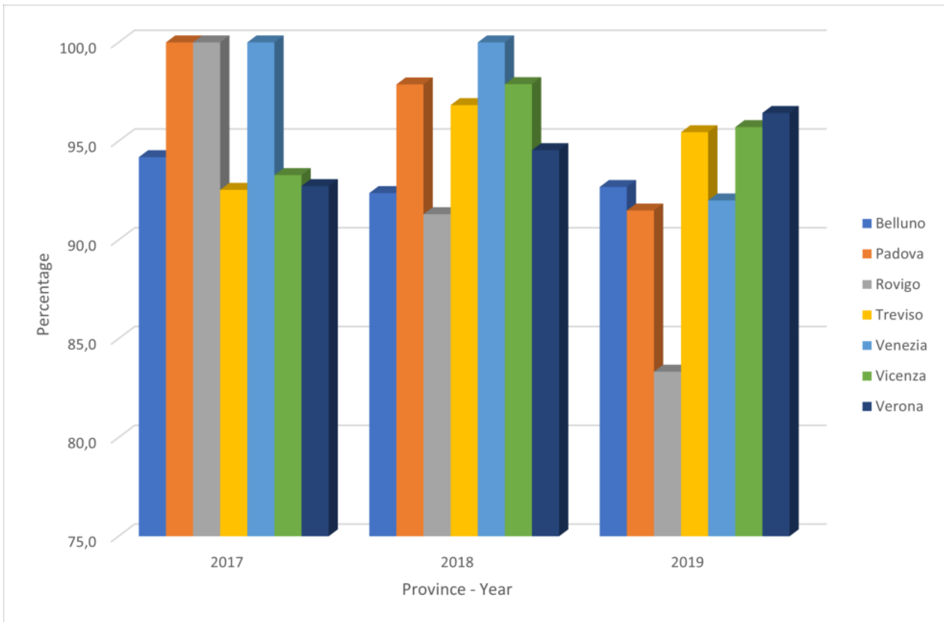


Chart 19. *Veneto Region: Percentage distribution of active enterprises over the total, in the sector of silviculture and use of forestry areas. Source: own elaboration based on Movimprese database*

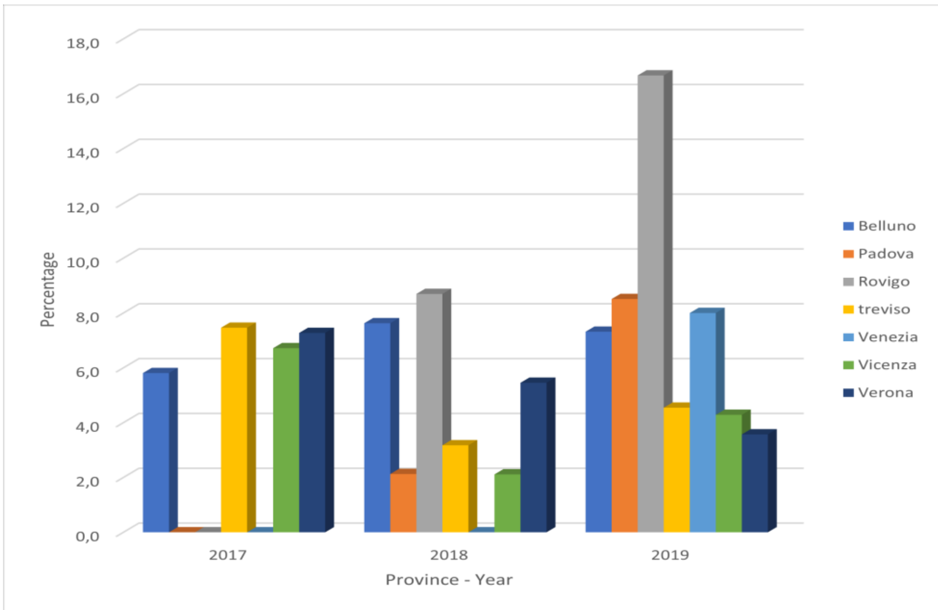


Chart 20. *Veneto Region: Percentage distribution of ceased enterprises over the total, in the sector of silviculture and use of forestry area.- Source: own elaboration based on Movimprese database*

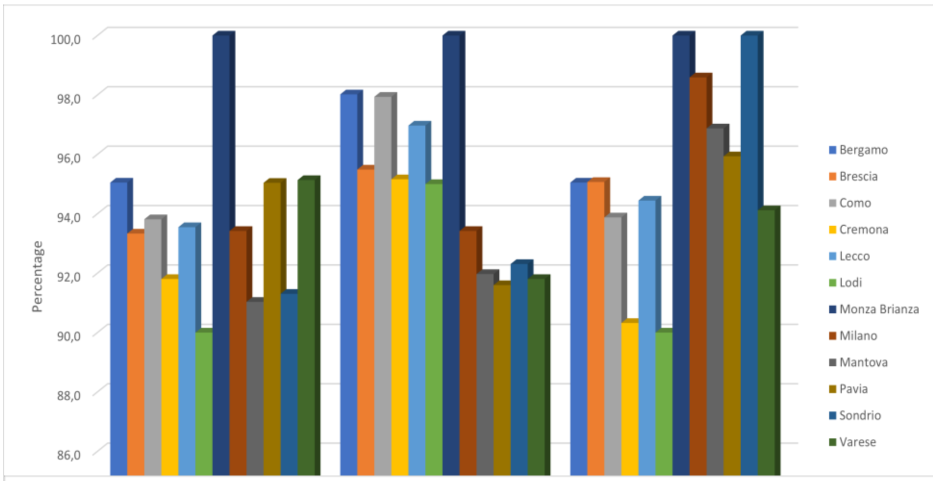


Chart 21. *Lombardy Region: Percentage distribution of active enterprises over the total, in the sector of silviculture and use of forestry areas. Source: own elaboration based on Movimprese database*

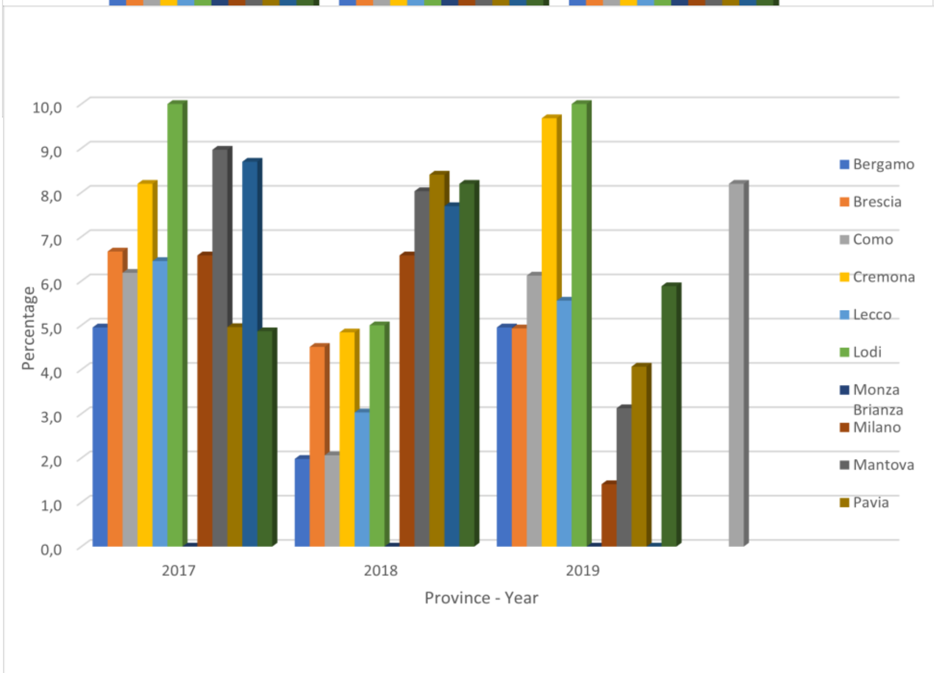


Chart 22. *Lombardy Region: Percentage distribution of ceased enterprises over the total, in the sector of silviculture and use of forestry areas. Source: own elaboration based on Movimprese database*

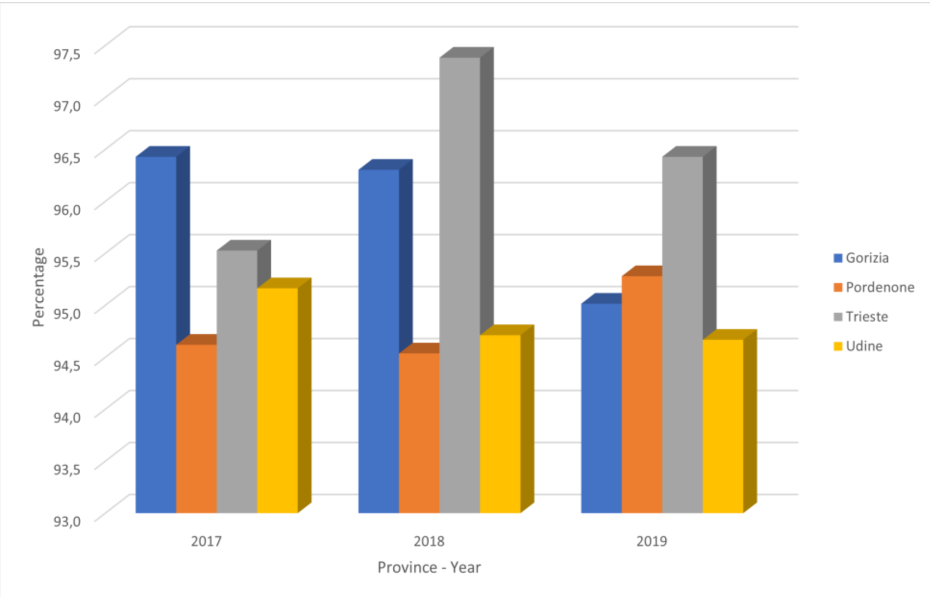


Chart 23. *Friuli Region: Percentage distribution of active enterprises over the total, in the sector of agriculture and animal products. Source: own elaboration based on Movimprese database*

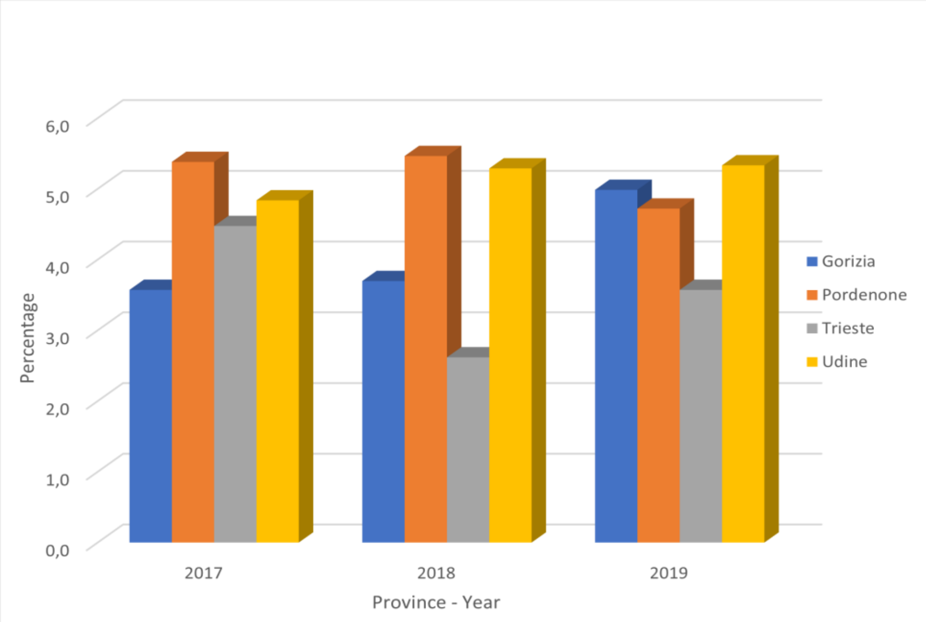


Chart 24. *Friuli Region: Percentage distribution of ceased enterprises over the total, in the sector of agriculture and animal products. Source: own elaboration based on Movimprese database*

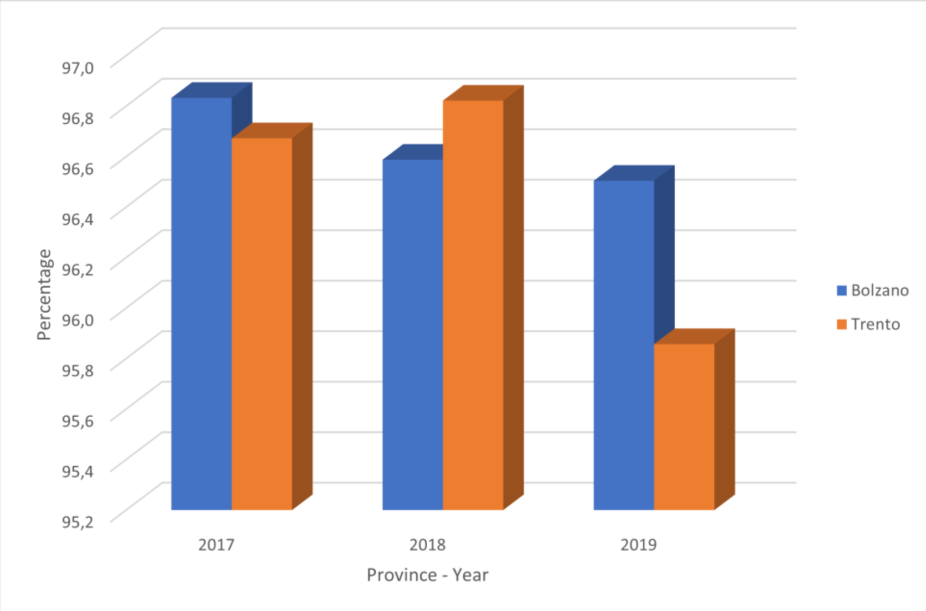


Chart 25. *Trentino A.A. Region: Percentage distribution of active enterprises over the total, in the sector of agriculture and animal products. Source: own elaboration based on Movimprese database*

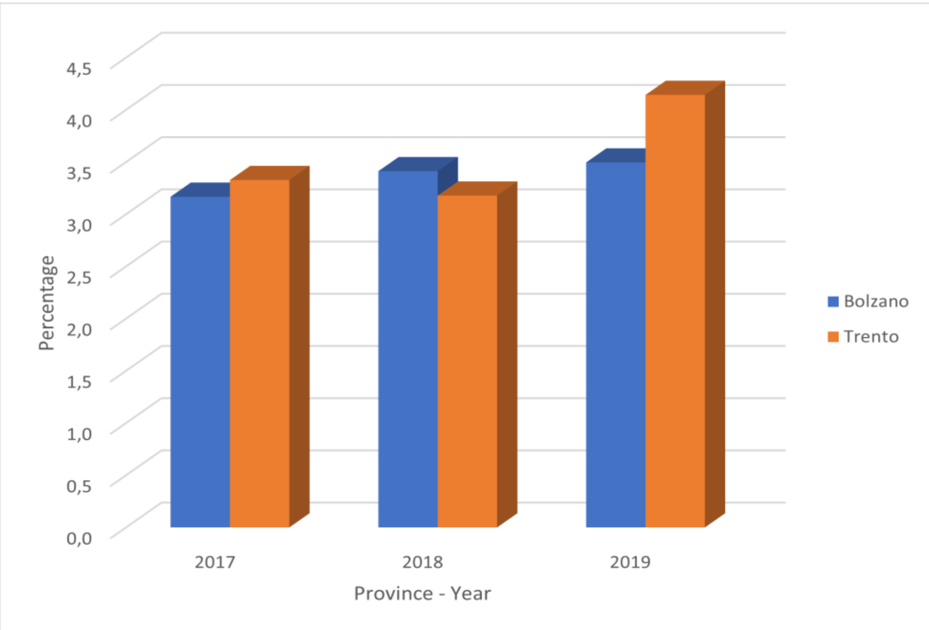


Chart 26. *Trentino A.A. Region: Percentage distribution of ceased enterprises over the total, in the sector of agriculture and animal products. Source: own elaboration based on Movimprese database*

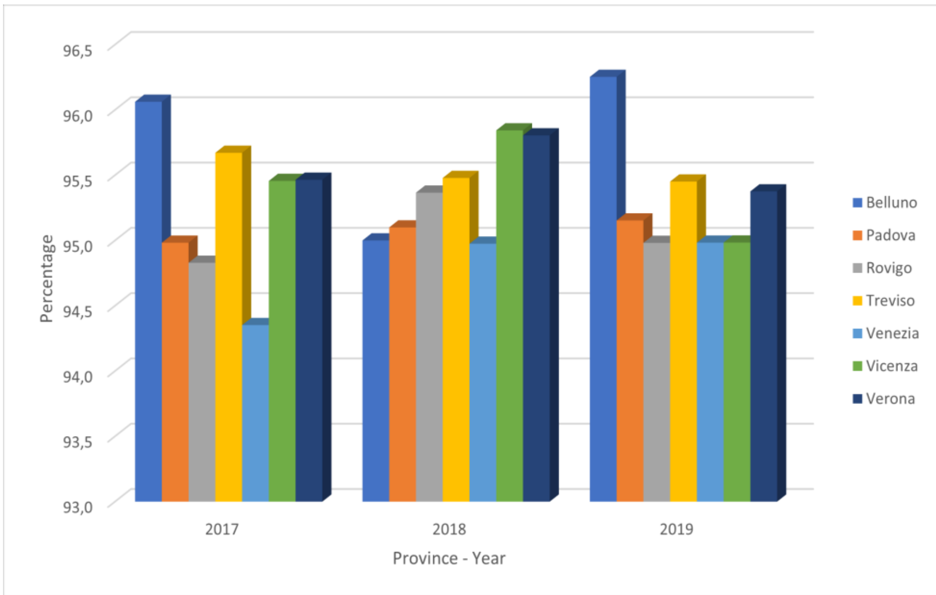


Chart 27. *Veneto. Region: Percentage distribution of active enterprises over the total, in the sector of agriculture and animal products. Source: own elaboration based on Movimprese database*

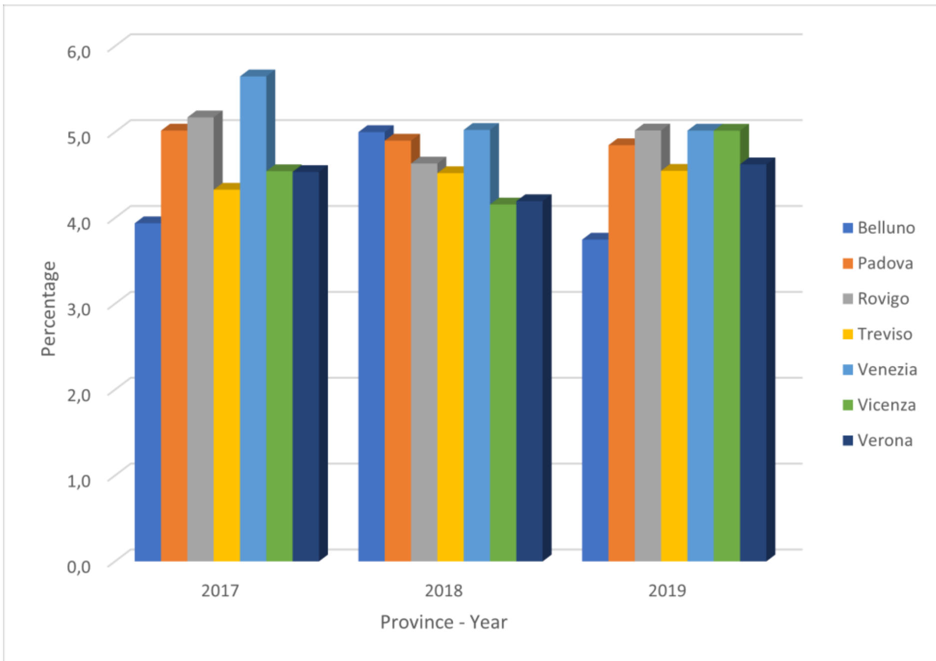


Chart 28. *Veneto. Region: Percentage distribution of ceased enterprises over the total, in the sector of agriculture and animal products. Source: own elaboration based on Movimprese database*

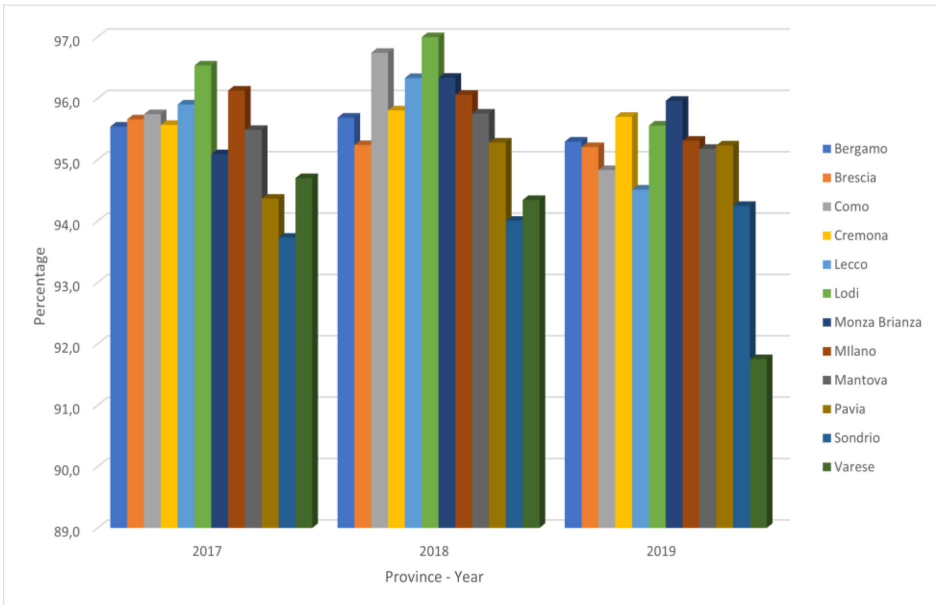


Chart 29. *Lombardy Region: Percentage distribution of active enterprises over the total, in the sector of agriculture and animal products. Source: own elaboration based on Movimprese database*

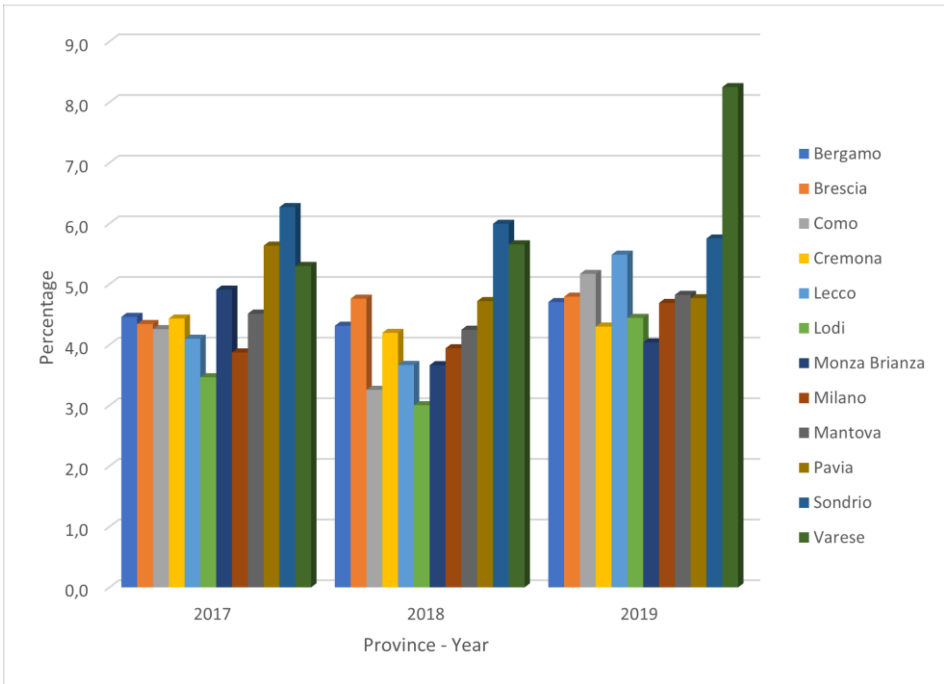


Chart 30. *Lombardy Region: Percentage distribution of ceased enterprises over the total, in the sector of agriculture and animal products. Source: own elaboration based on Movimprese database*

C. Provincial trend comparisons charts of secondary sectors

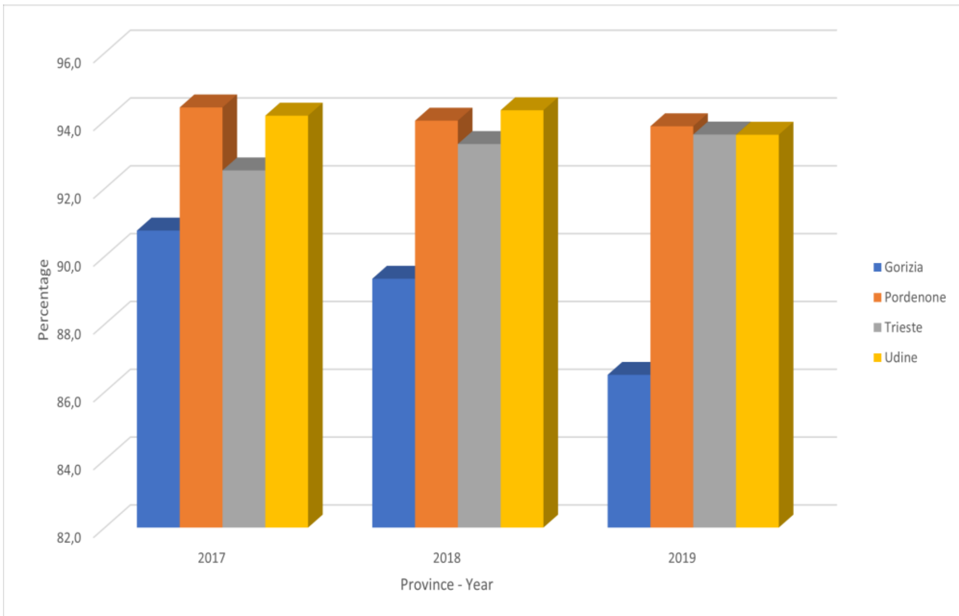


Chart 31. *Friuli Region: Percentage distribution of active enterprises over the total, in the sector of constructions. Source: own elaboration based on Movimprese database*

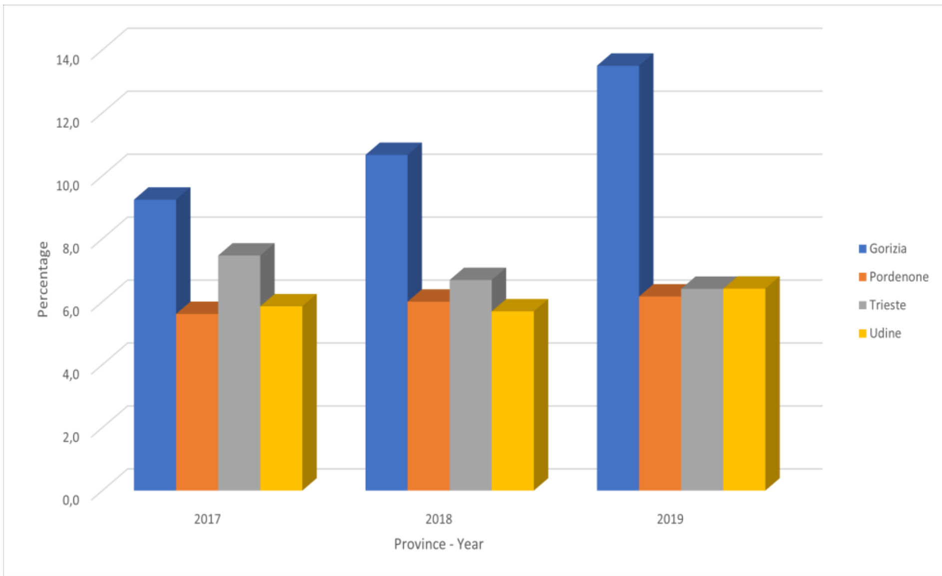


Chart 32. *Friuli Region: Percentage distribution of ceased enterprises over the total, in the sector of constructions. Source: own elaboration based on Movimprese database*

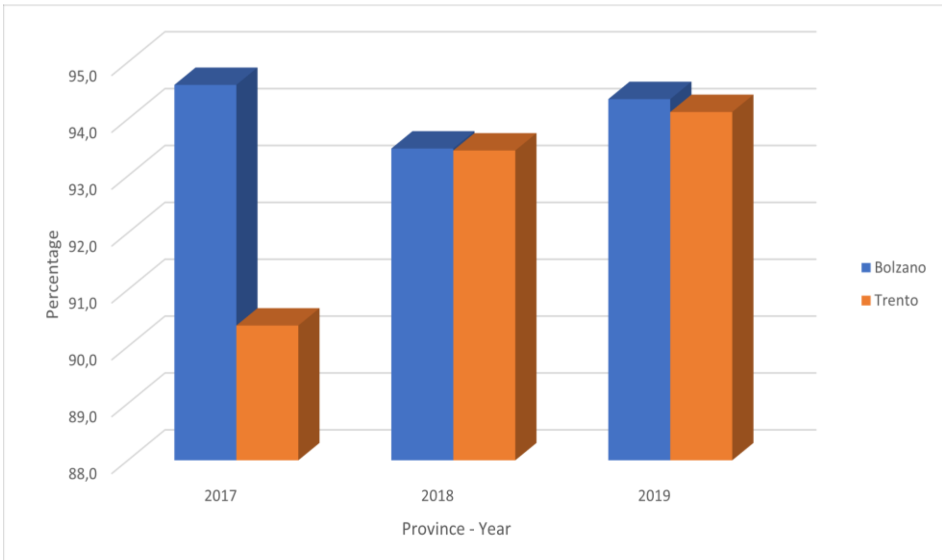


Chart 33. *Trentino A.A. Region: Percentage distribution of active enterprises over the total, in the sector of constructions. Source: own elaboration based on Movimprese database*

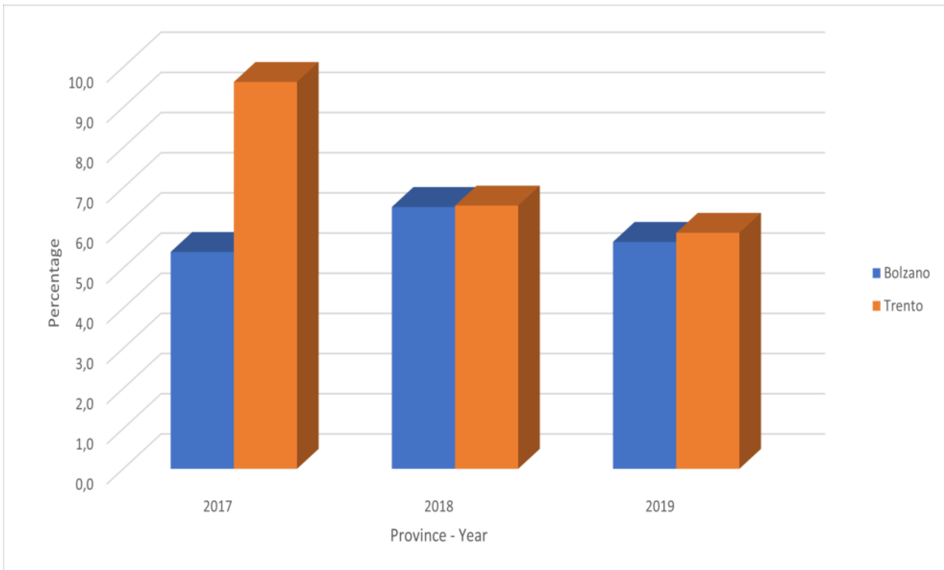


Chart 34. *Trentino A.A. Region: Percentage distribution of ceased enterprises over the total, in the sector of constructions. Source: own elaboration based on Movimprese database*

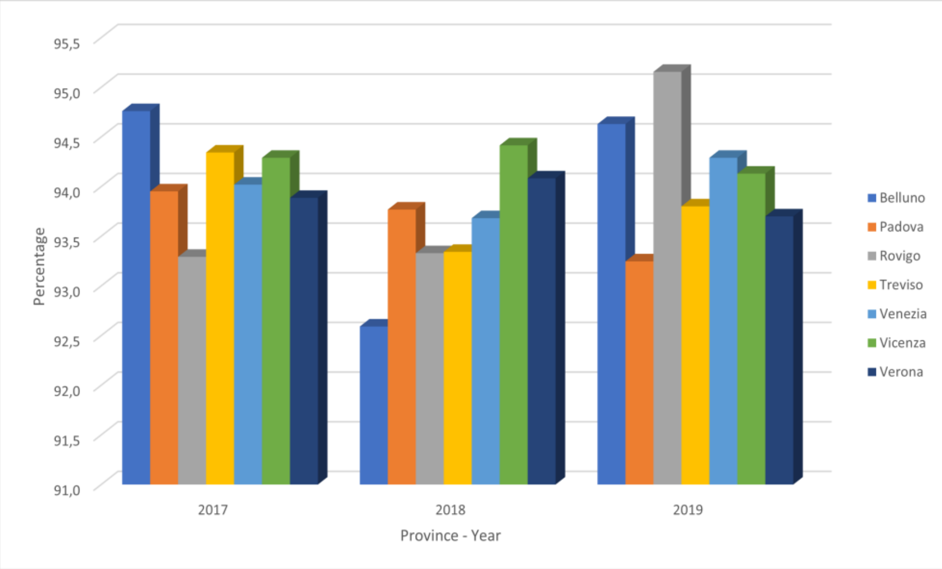


Chart 35. *Veneto Region: Percentage distribution of active enterprises over the total, in the sector of constructions. Source: own elaboration based on Movimprese database*

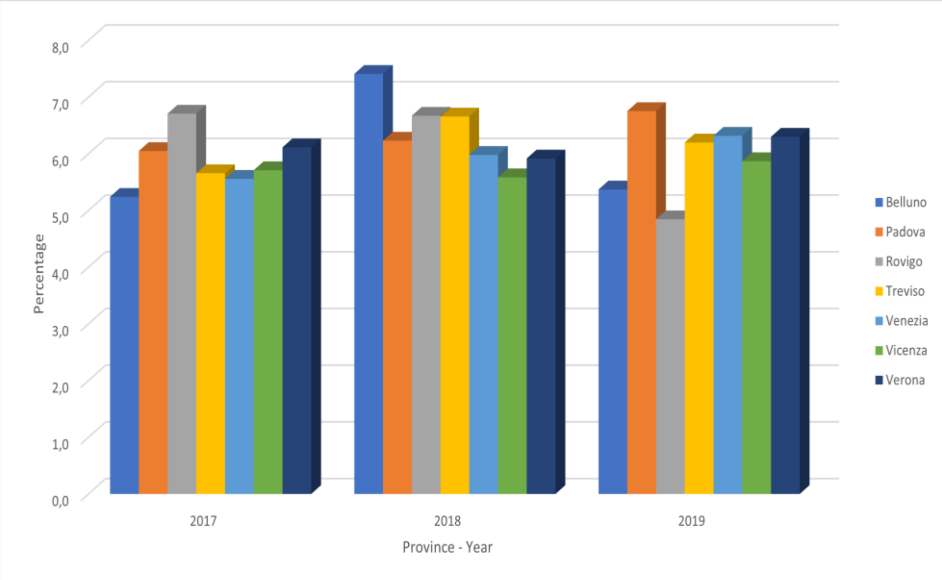


Chart 36. *Veneto Region: Percentage distribution of ceased enterprises over the total, in the sector of constructions. Source: own elaboration based on Movimprese database*

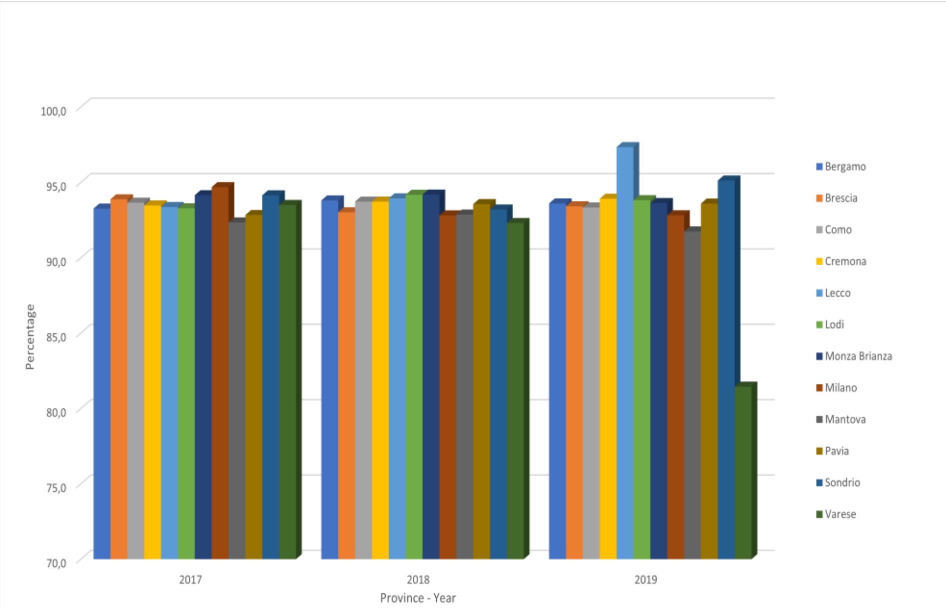


Chart 37. *Lombardy. Region: Percentage distribution of active enterprises over the total, in the sector of constructions. Source: own elaboration based on Movimprese database*

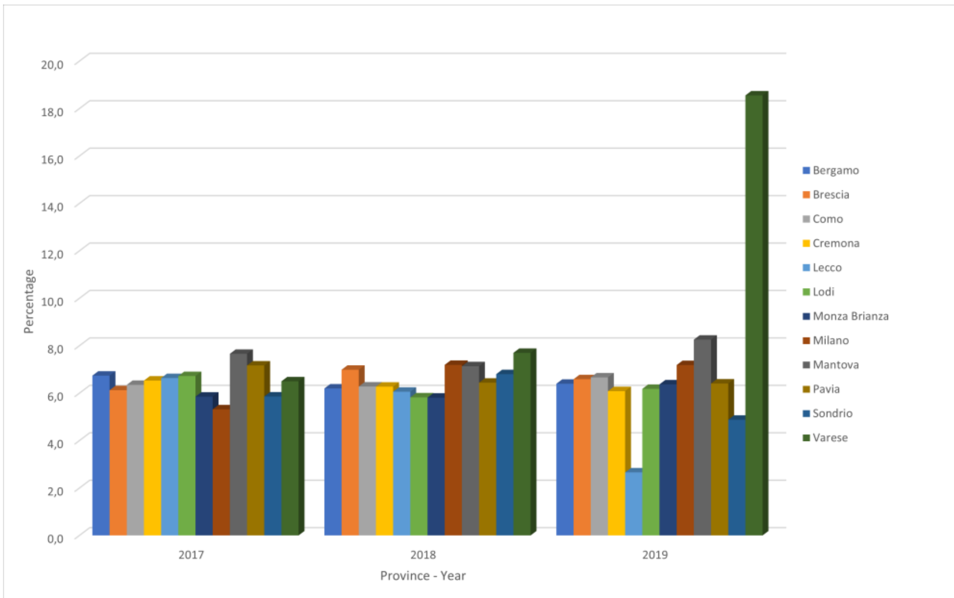


Chart 38. *Lombardy Region: Percentage distribution of ceased enterprises over the total, in the sector of constructions. Source: own elaboration based on Movimprese database*

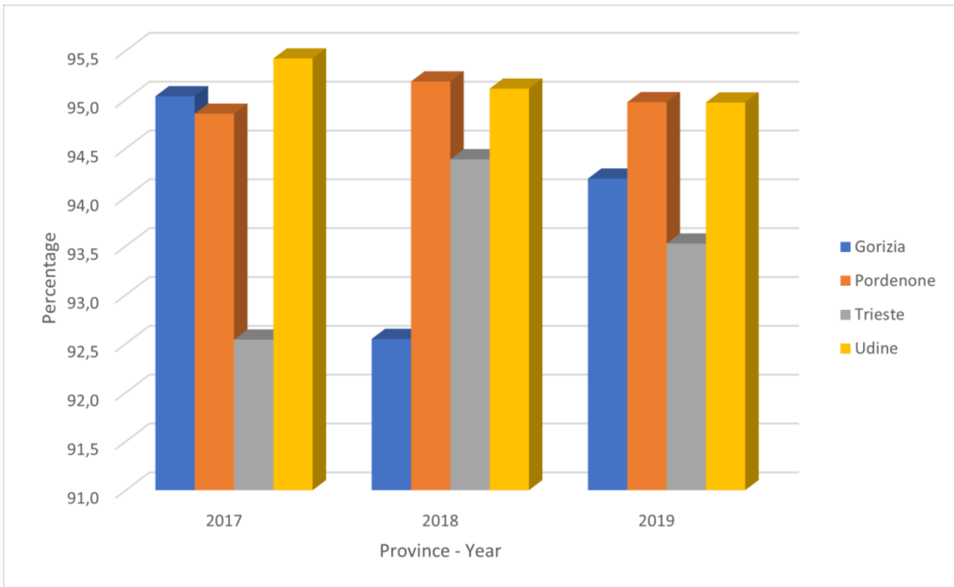
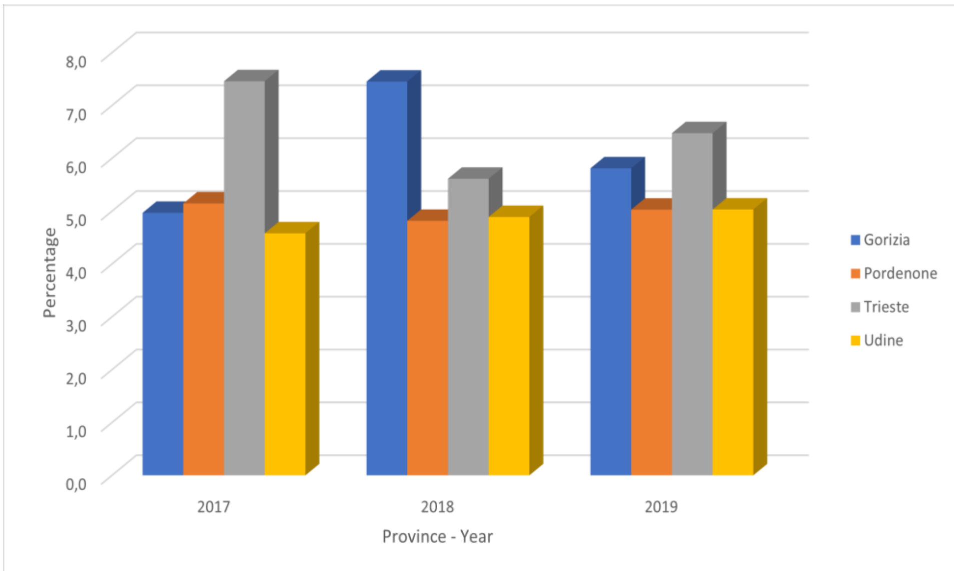


Chart 39. *Friuli Region: Percentage distribution of active enterprises over the total, in the sector of manufacture. Source: own elaboration based on Movimprese database*



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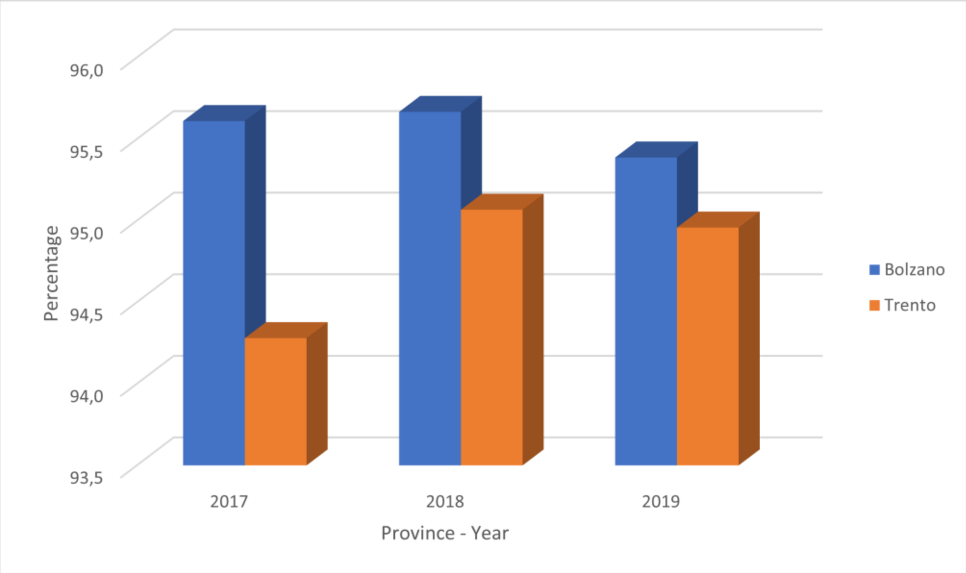


Chart 41. *Trentino A.A. Region: Percentage distribution of active enterprises over the total, in the sector of manufacture. Source: own elaboration based on Movimprese database*

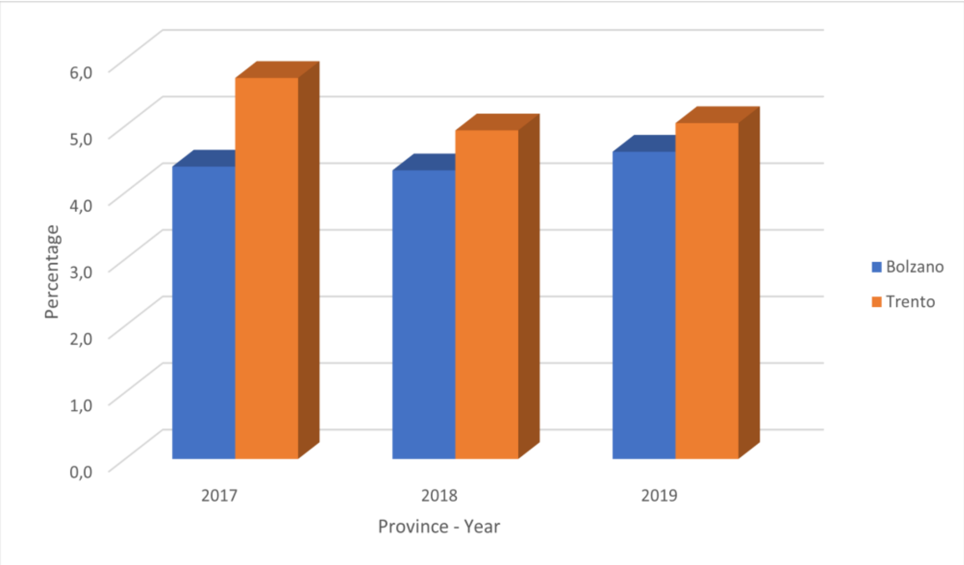


Chart 42. *Trentino A.A. Region: Percentage distribution of ceased enterprises over the total, in the sector of manufacture. Source: own elaboration based on Movimprese database*

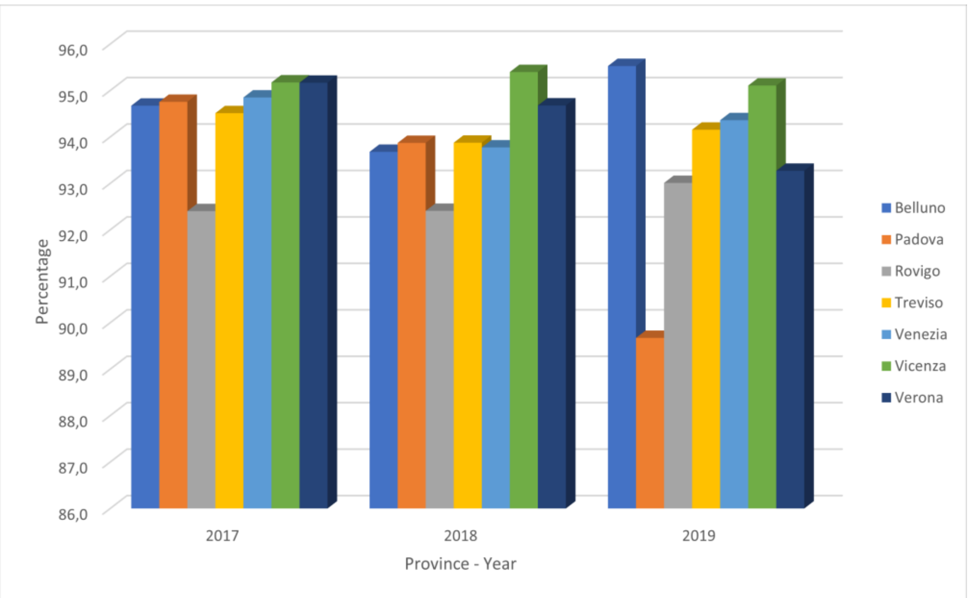


Chart 43. *Veneto Region: Percentage distribution of active enterprises over the total, in the sector of manufacture. Source: own elaboration based on Movimprese database*

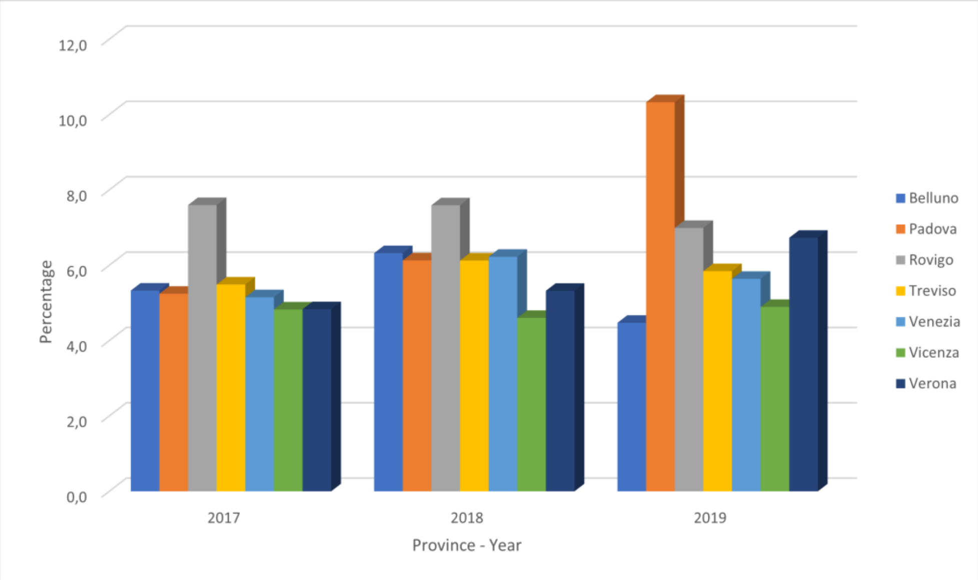


Chart 44. *Veneto Region. Percentage distribution of ceased enterprises over the total, in the sector of manufacture. Source: own elaboration based on Movimprese database*

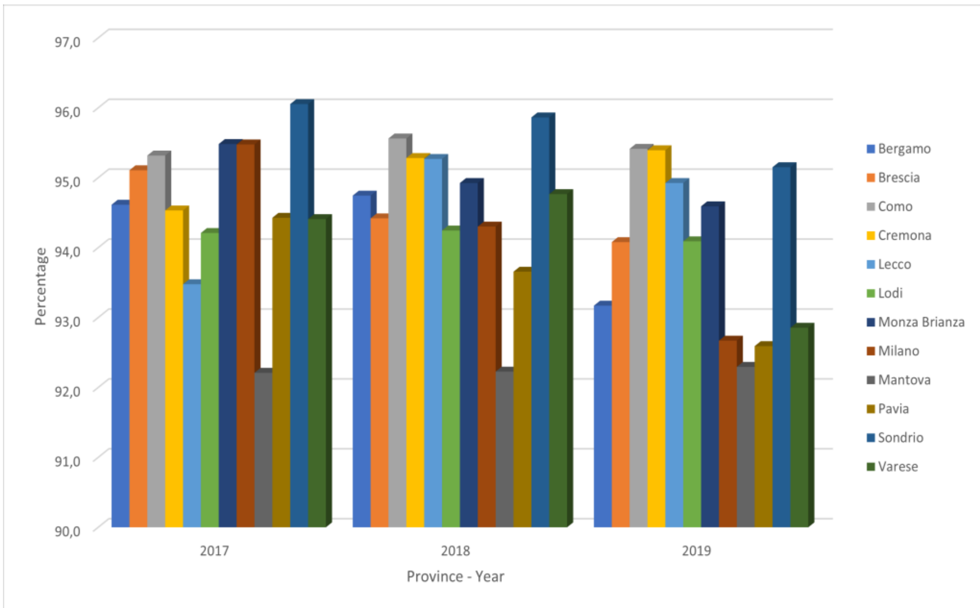


Chart 45. *Lombardy Region: Percentage distribution of active enterprises over the total, in the sector of manufacture. Source: own elaboration based on Movimprese database*

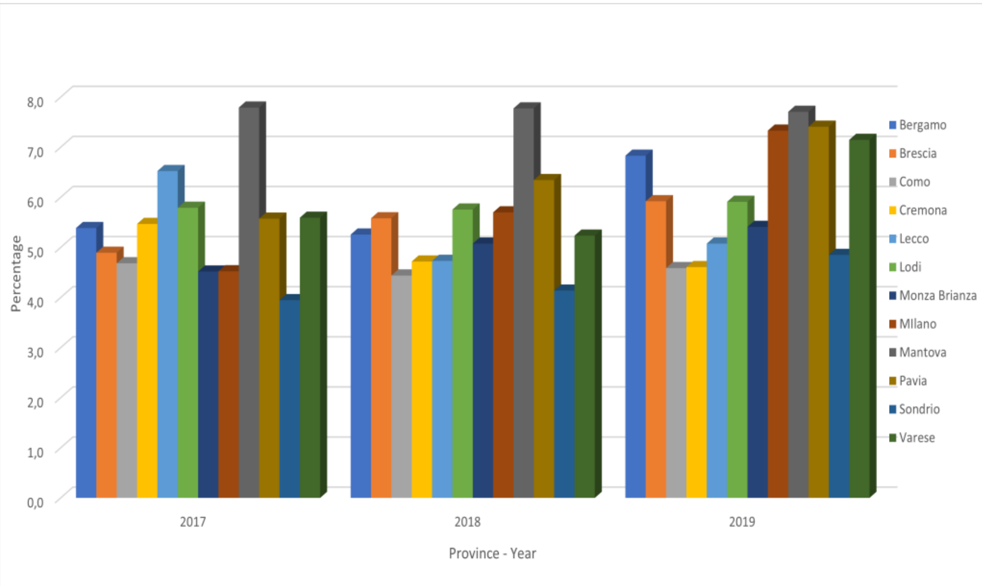


Chart 46. *Lombardy Region: Percentage distribution of ceased enterprises over the total, in the sector of manufacture. Source: own elaboration based on Movimprese database*

D. Provincial trend comparisons charts of tertiary sector

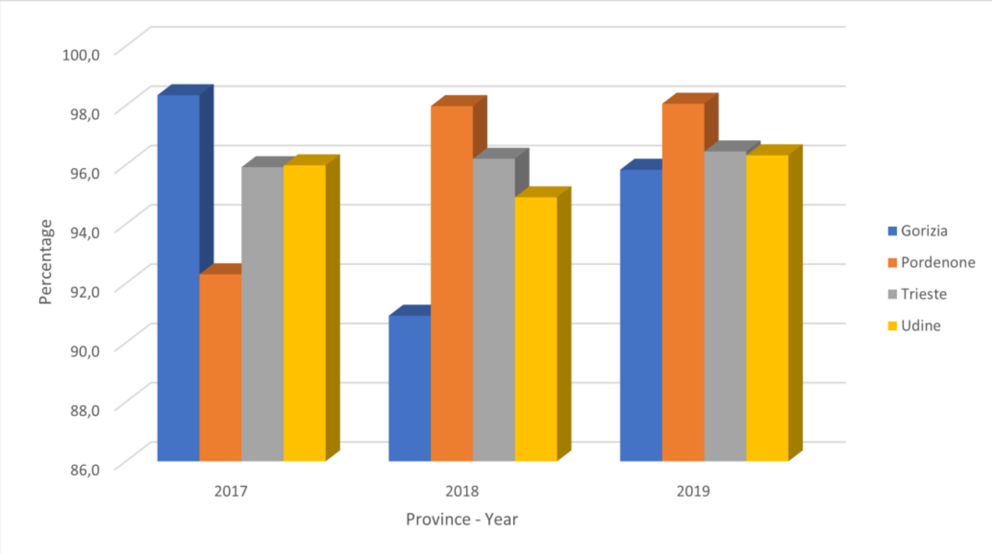


Chart 47. *Friuli Region: Percentage distribution of active enterprises over the total, in the sector of accommodations. Source: own elaboration based on Movimprese database*

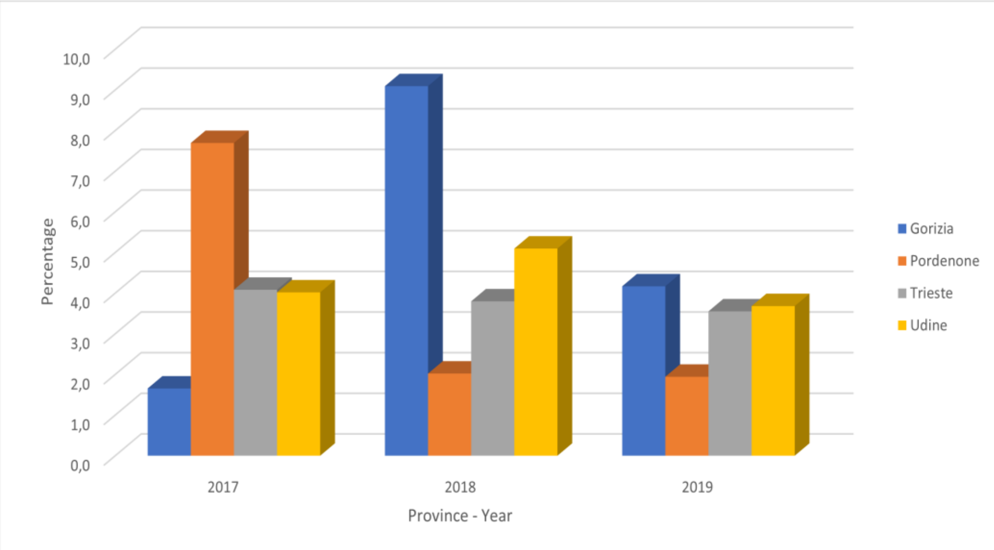


Chart 48. *Friuli Region: Percentage distribution of ceased enterprises over the total, in the sector of accommodations. Source: own elaboration based on Movimprese database*

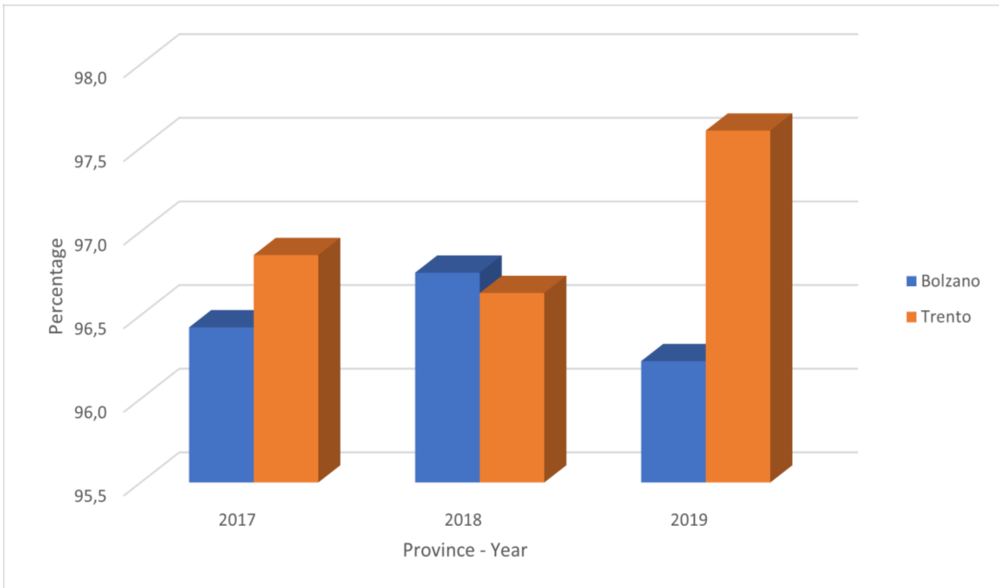
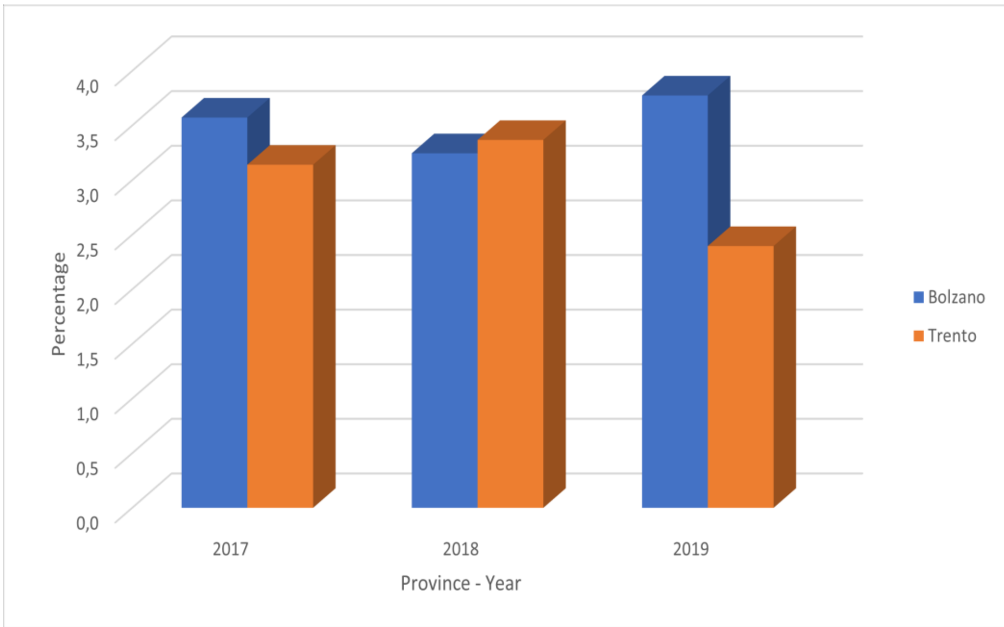


Chart 49. *Trentino A.A. Region: Percentage distribution of active enterprises over the total, in the sector of accommodations. Source: own elaboration based on Movimprese database*



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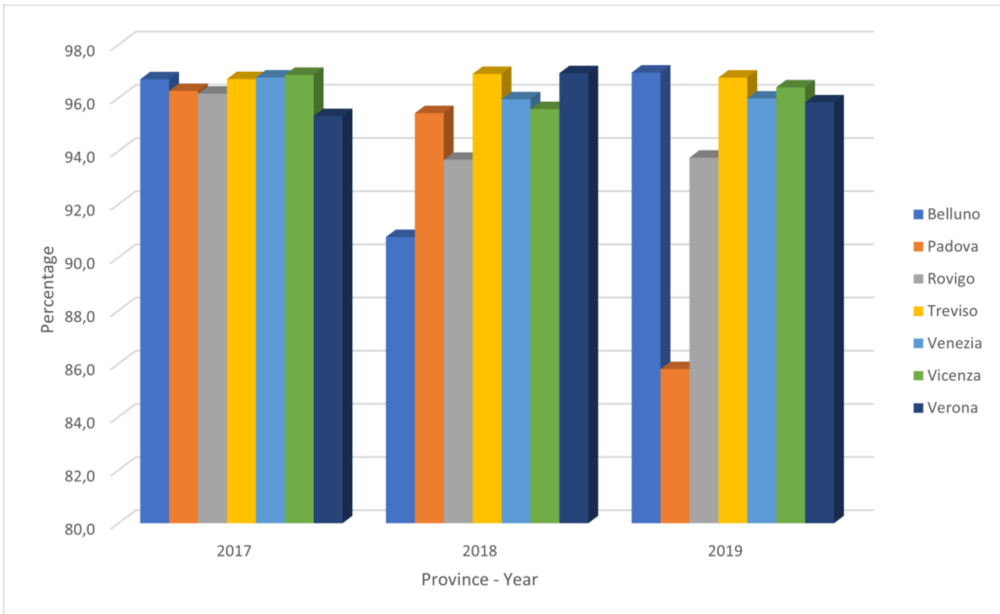

Chart 51. *Veneto Region: Percentage distribution of active enterprises over the total, in the sector of accommodations. Source: own elaboration based on Movimprese database*

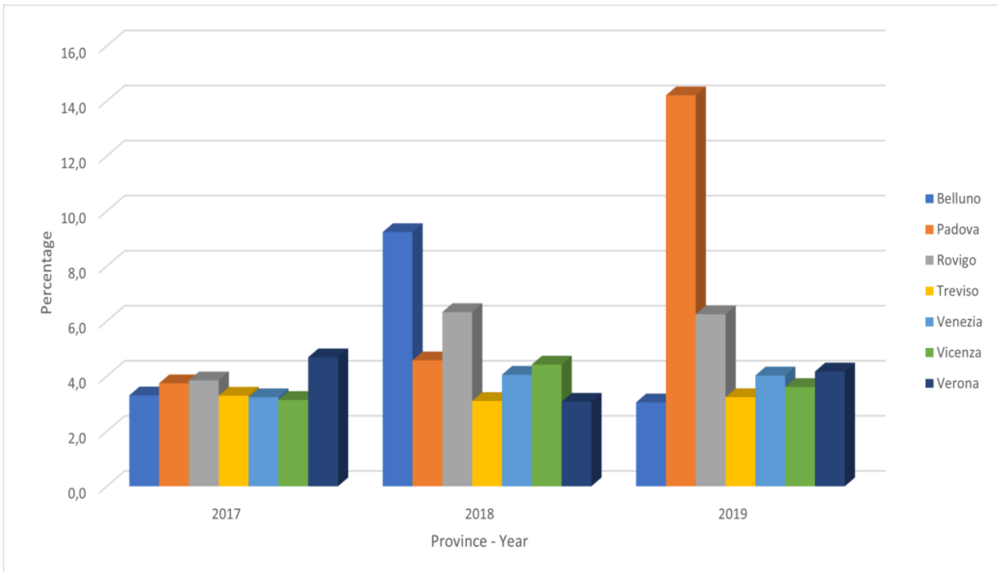

Chart 52. *Veneto Region: Percentage distribution of ceased enterprises over the total, in the sector of accommodations. Source: own elaboration based on Movimprese database*

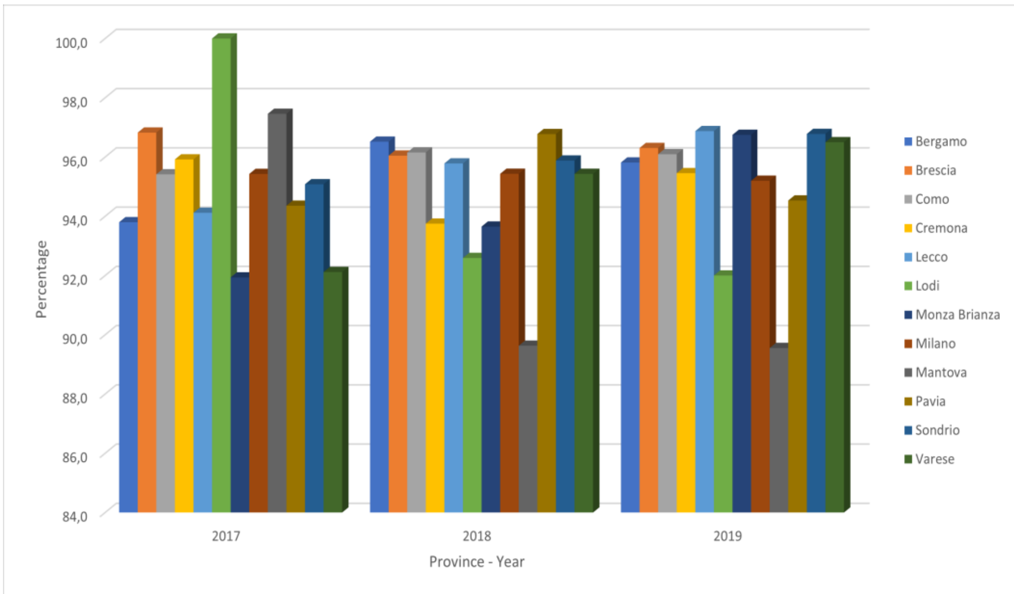

Chart 53. *Lombardy Region: Percentage distribution of active enterprises over the total, in the sector of accommodations. Source: own elaboration based on Movimprese database*

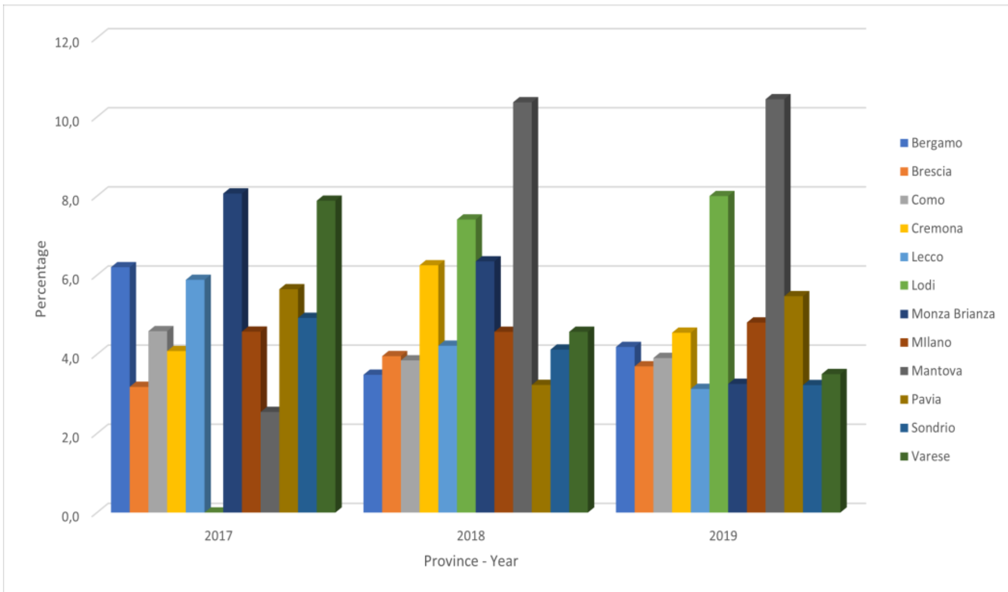

Chart 54. *Lombardy Region: Percentage distribution of ceased enterprises over the total, in the sector of accommodations. Source: own elaboration based on Movimprese database*

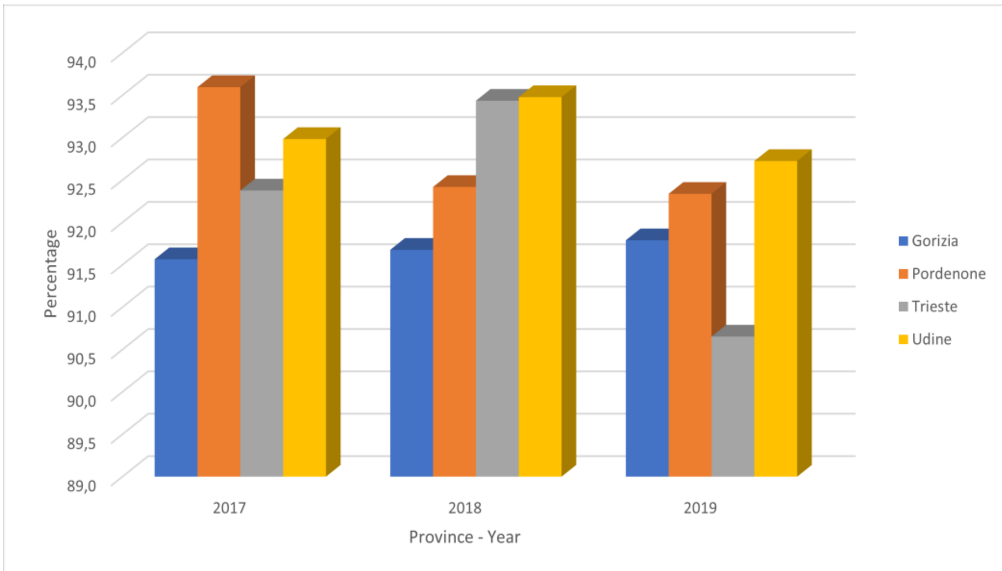

Chart 55. *Friuli Region: Percentage distribution of active enterprises over the total, in the sector of catering. Source: own elaboration based on Movimprese database*

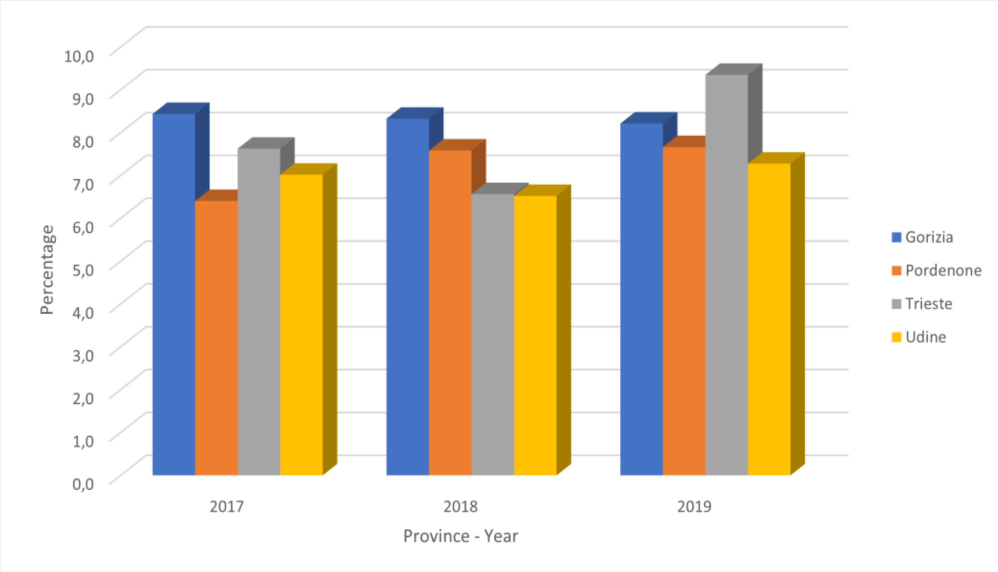

Chart 56. *Friuli Region: Percentage distribution of ceased enterprises over the total, in the sector of catering. Source: own elaboration based on Movimprese database*

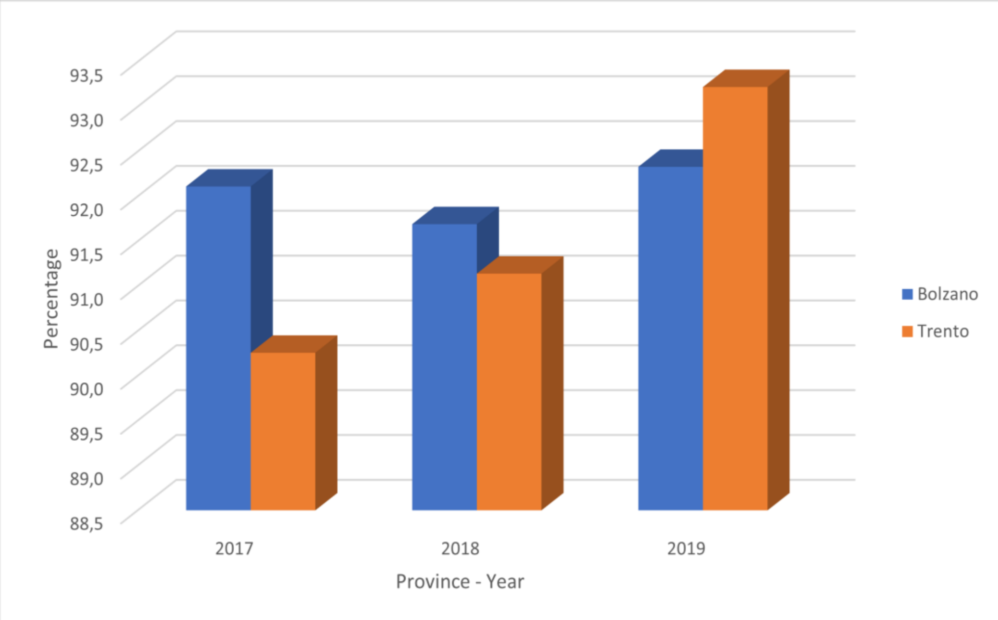

Chart 57. *Trentino A.A. Region: Percentage distribution of active enterprises over the total, in the sector of catering. Source: own elaboration based on Movimprese database*

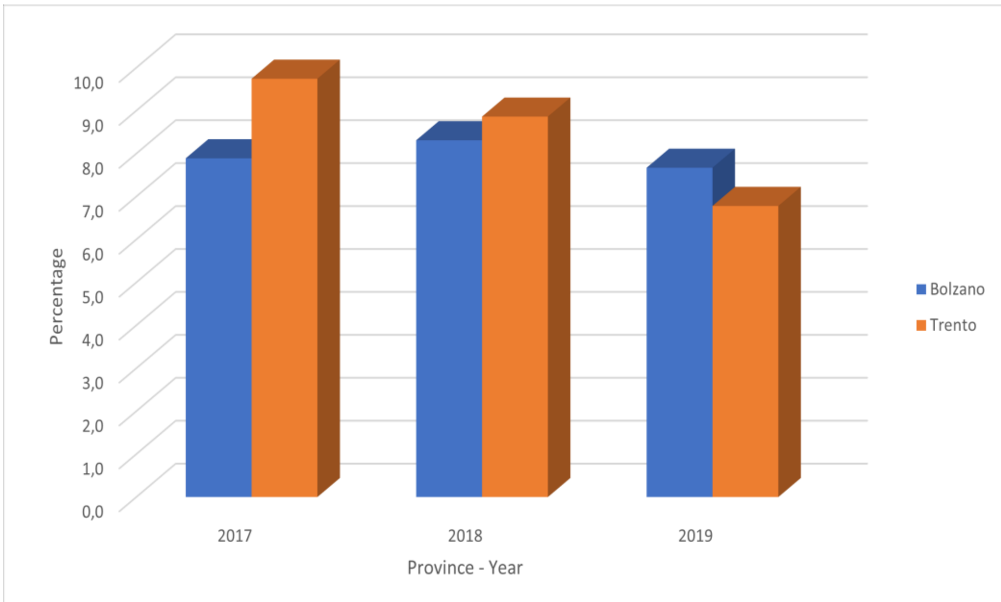

Chart 58. *Trentino A.A. Region: Percentage distribution of ceased enterprises over the total, in the sector of catering. Source: own elaboration based on Movimprese database*

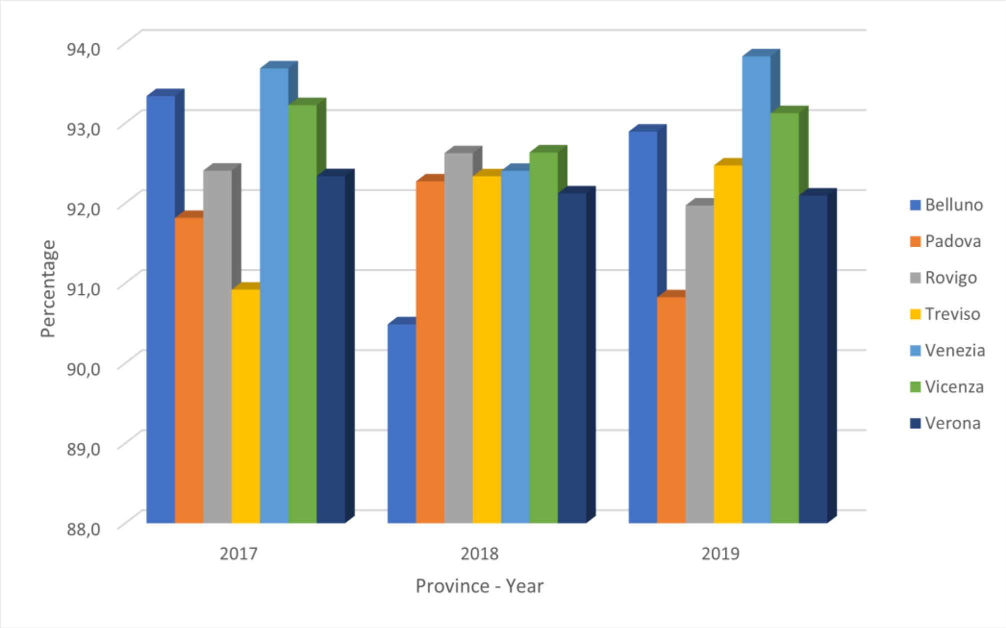

Chart 59. *Veneto Region: Percentage distribution of active enterprises over the total, in the sector of catering. Source: own elaboration based on Movimprese database*

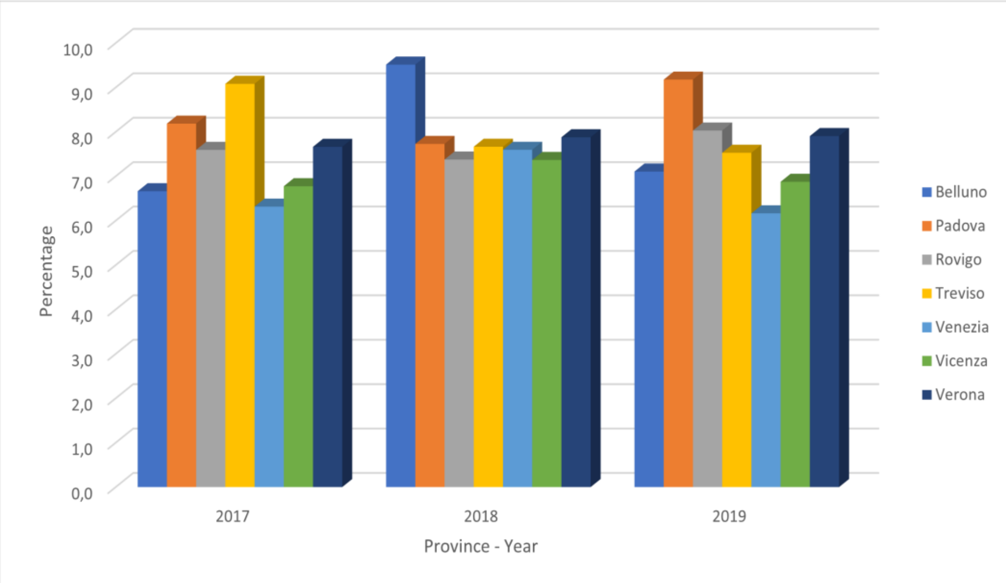

Chart 60. *Veneto Region: Percentage distribution of ceased enterprises over the total, in the sector of catering. Source: own elaboration based on Movimprese database*

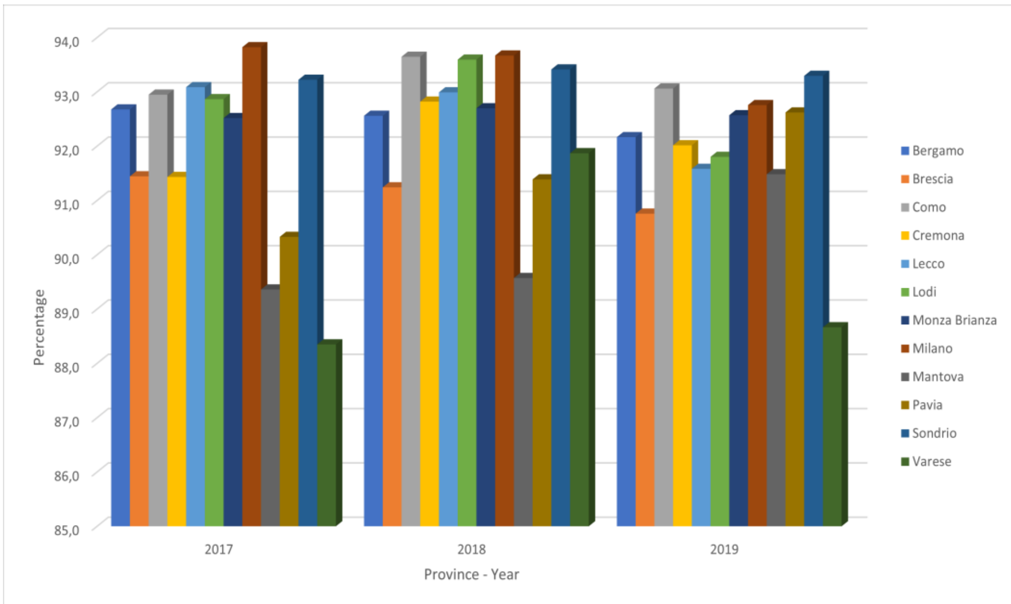

Chart 61. *Lombardy Region: Percentage distribution of active enterprises over the total, in the sector of catering. Source: own elaboration based on Movimprese database*

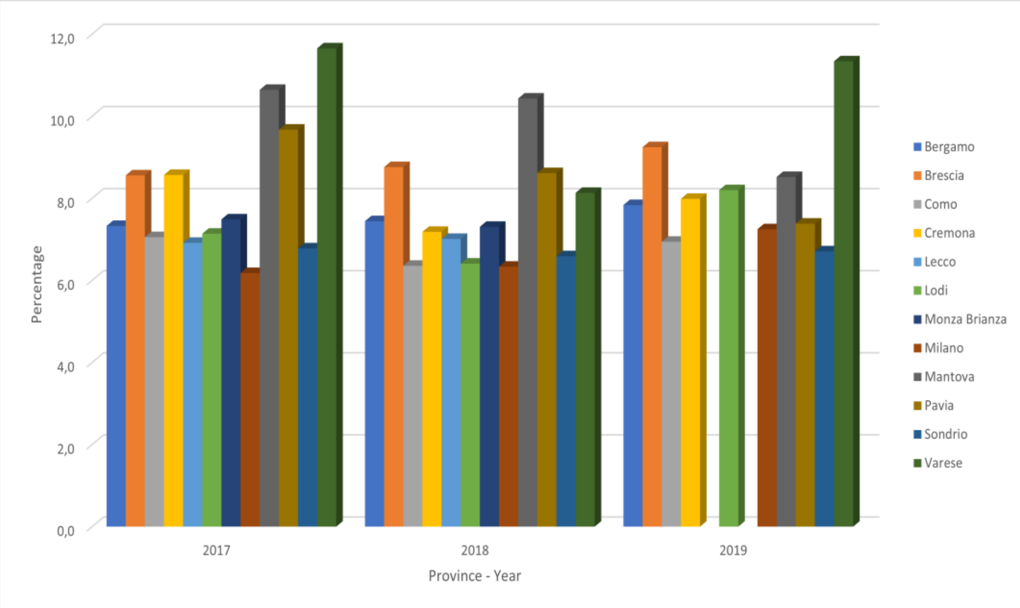

Chart 62. *Lombardy Region: Percentage distribution of ceased enterprises over the total, in the sector of catering. Source: own elaboration based on Movimprese database*

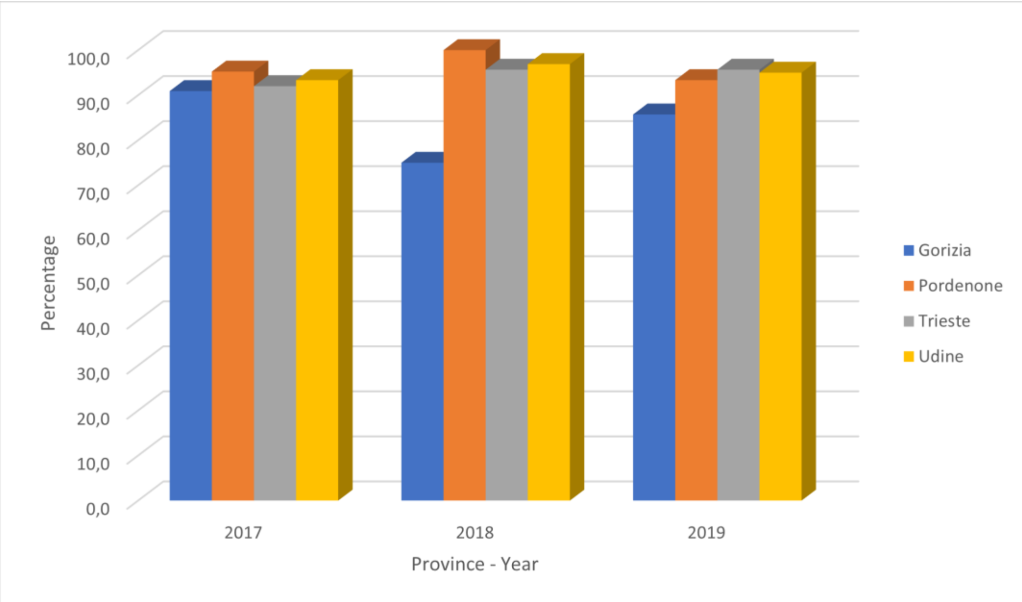

Chart 63. *Friuli Region: Percentage distribution of active enterprises over the total, in the sector of energy supply services. Source: own elaboration based on Movimprese database*

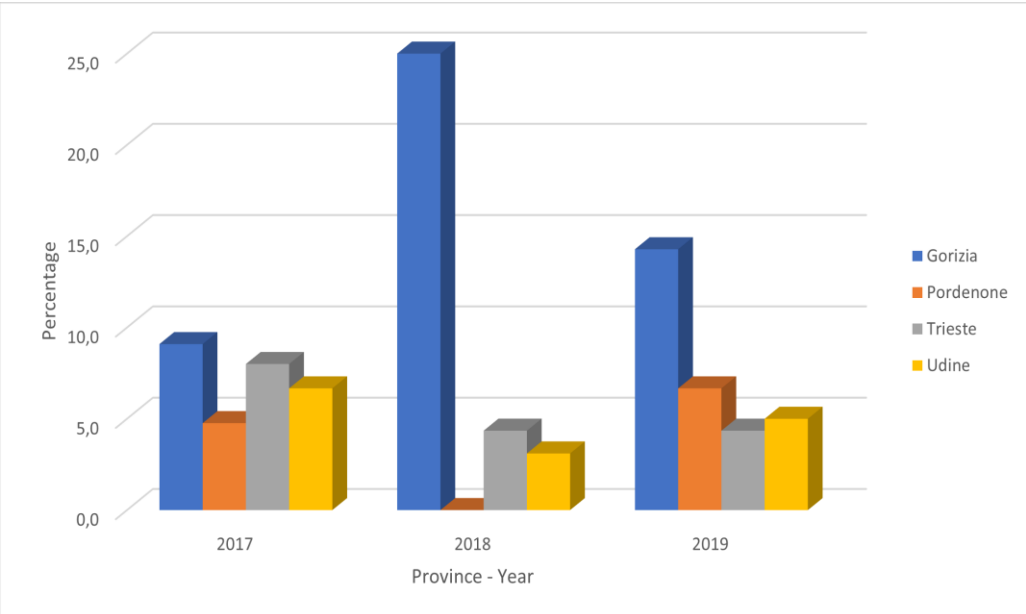

Chart 64. *Friuli Region: Percentage distribution of ceased enterprises over the total, in the sector of energy supply services. Source: own elaboration based on Movimprese database*

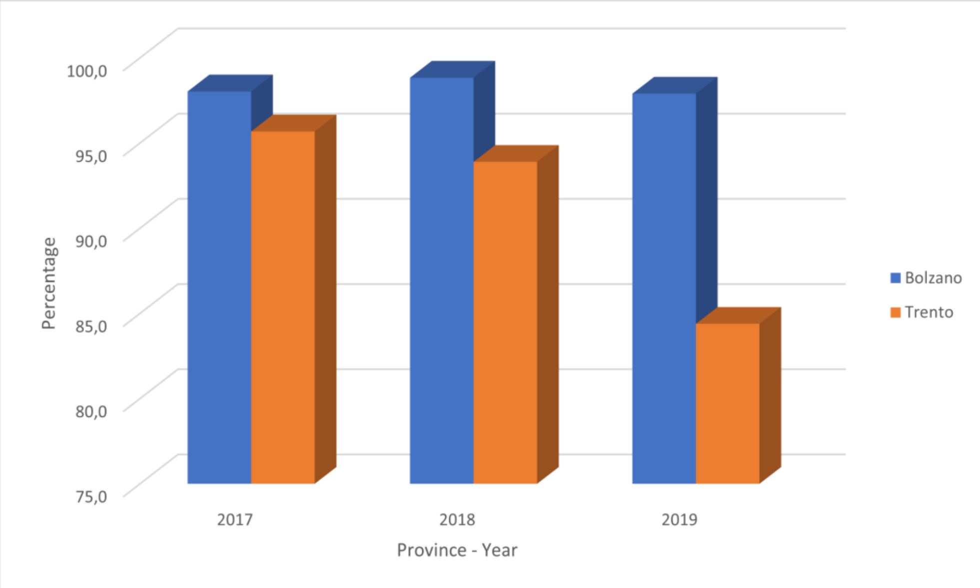

Chart 65. *Trentino A.A. Region: Percentage distribution of active enterprises over the total, in the sector of energy supply services. Source: own elaboration based on Movimprese database*

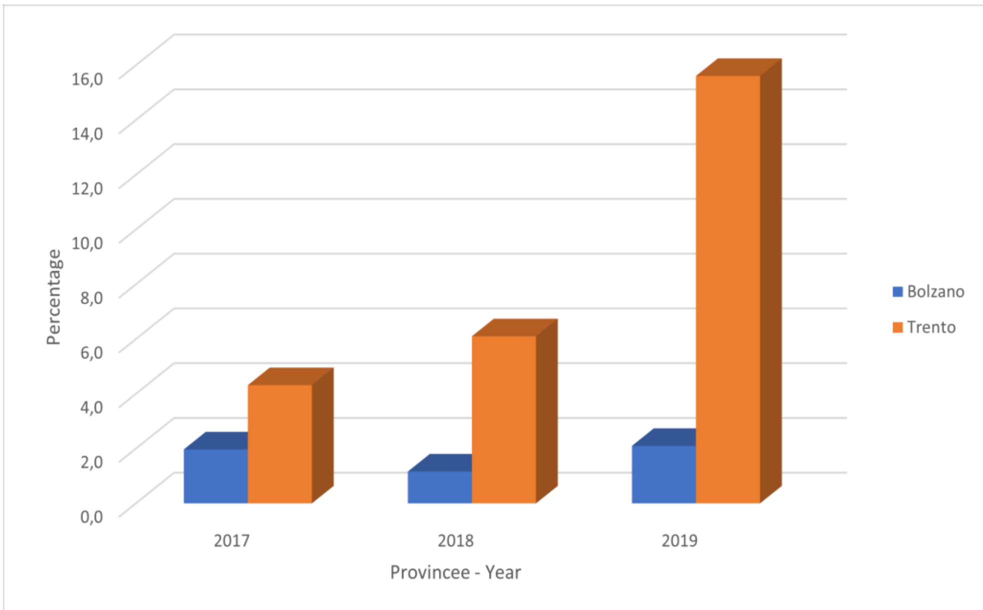

Chart 66. *Trentino A.A. Region: Percentage distribution of ceased enterprises over the total, in the sector of energy supply services. Source: own elaboration based on Movimprese database*

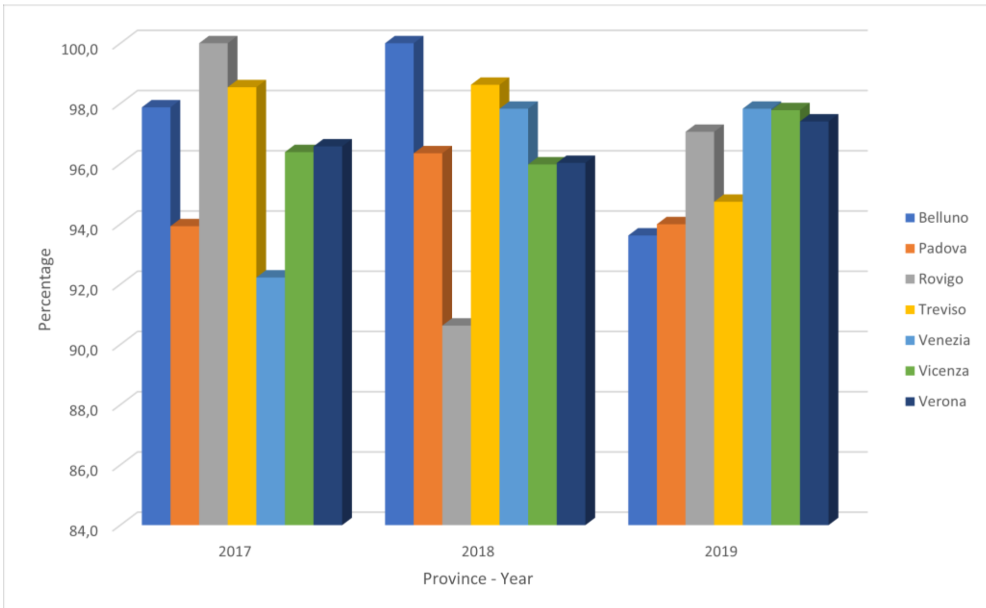

Chart 67. *Veneto Region: Percentage distribution of active enterprises over the total, in the sector of energy supply services. Source: own elaboration based on Movimprese database*

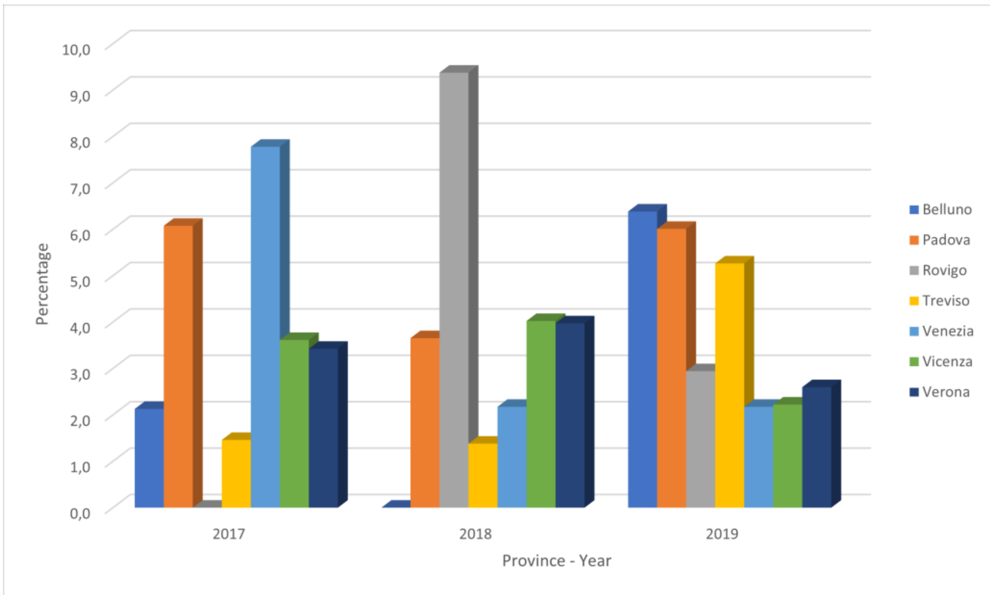

Chart 68. *Veneto Region: Percentage distribution of ceased enterprises over the total, in the sector of energy supply services. Source: own elaboration based on Movimprese database*

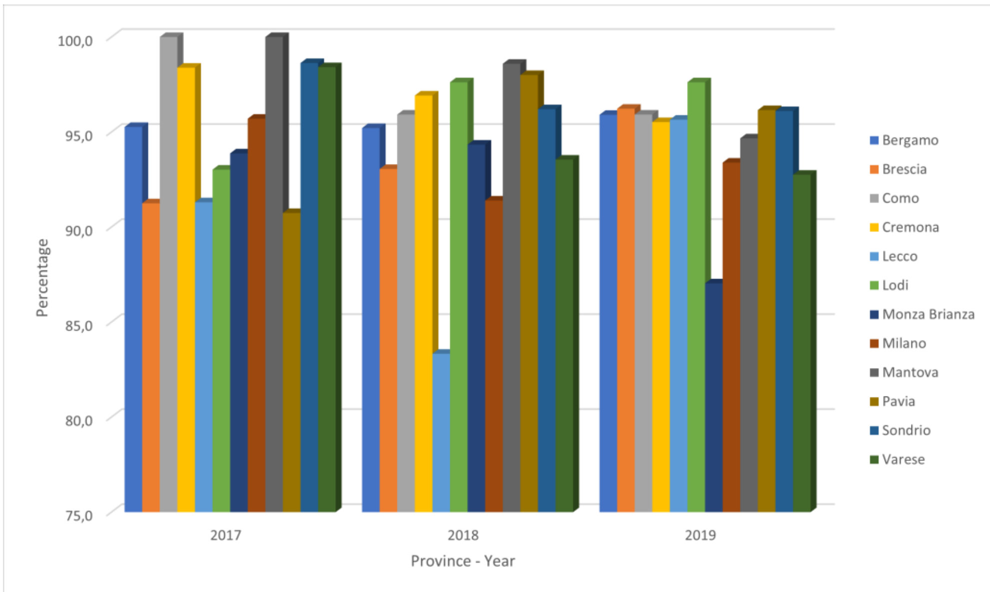

Chart 69. *Lombardy Region: Percentage distribution of active enterprises over the total, in the sector of energy supply services. Source: own elaboration based on Movimprese database*

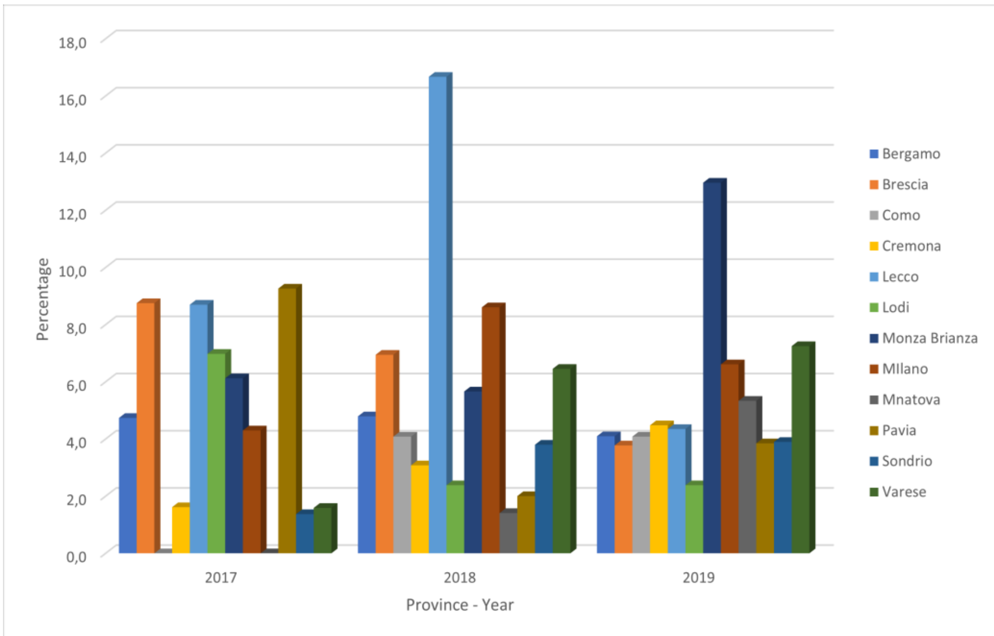

Chart 70. *Lombardy Region: Percentage distribution of ceased enterprises over the total, in the sector of energy supply services. Source: own elaboration based on Movimprese database*

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