Socio-economic and institutional effects of windstorms damaging forests: preliminary observations from European cases and Vaia windstorm

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Summary

Climate change effects, including more frequent and intense extreme weather events, are increasingly threatening societal, environmental and economic wellbeing at global scale. Projections unanimously predict an increase in climate change intensity over the next years. Windstorms are considered among the most impacting natural events for European forests and forest socio-ecological systems, and their frequency as well as severity are expected to increase in the context of climate change. Among the most recent windstorms in Europe, Vaia windstorm hit North-Eastern Italy in 2018, destroying some 43,000 ha of forests and totalling 10 million m^3 of windfall timber. Although there is robust empirical evidence that windstorms have severe impacts on natural resources and socio-economic dimensions of local communities, ultimately threating their sustainability and resilience, there is a research gap in terms of cross-sectoral and multidimensional analysis of windstorm impacts. Despite the existence of a vast literature on wind-related natural disasters, dynamics and processes driving resilience at socio-ecological level in communities hit by storms have been poorly investigated so far. Socio-economic and institutional dimensions are rarely taken into consideration in post-windstorm analysis, thus creating a knowledge gap in the understanding of windstorm consequences in the medium to long term. The paper aims to contribute filling the current research and knowledge gap on socio-economic impacts of windstorms and the understanding of ways to achieve governance settings and mechanisms that allow developing effective solutions to improve resilience of fragile socio-ecological systems. The analysis of storm impacts as well post-event actions and dynamics can provide useful feedback to inform future policymaking, management arrangements and governance setting for forest resources, thus supporting the management of extreme events that are expected to become more and more common in the next future.

Keywords: windstorm, forest socio-ecological system, cause-effect linkages, forest-based communities, wood market

JEL Classification codes: Q51, Q54

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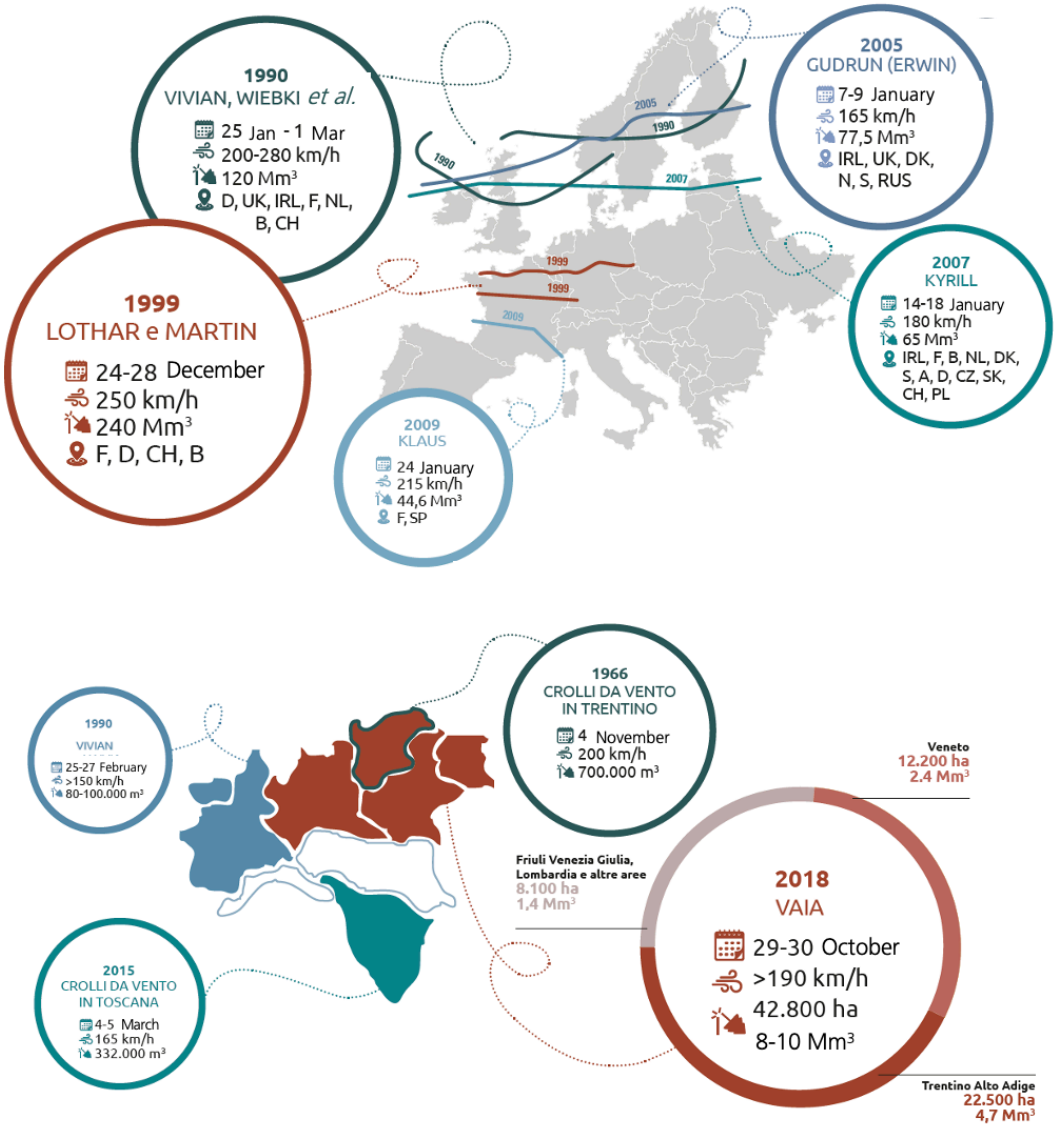
1. INTRODUCTION

Climate change is expected to produce long-term effects on forests (e.g. through higher temperatures, altered precipitation patterns etc.) and meanwhile increase the occurrence of extreme events directly/indirectly affecting forest resources. Windstorms, prolonged droughts, heat waves, fires etc. have increasingly occurred in the last decades (Seneviratne *et al*., 2012) and their impacts grown with the increase of the growing stock and average forest age observed across Europe. Wind is by far the most prominent among disturbances affecting European forests, being responsible for about 51% of all recorded damage (Schelnass, 2008) and totalling some 900 million m^3 windthrows since 1950s (Gardiner *et al*., 2103). Windstorms are relatively common in Central and Northern Europe, while in Southern European countries, like Italy, minor events took place even in recent years (Figure 1). However, on October 29th 2018, Vaia storm hit North-Eastern Italy damaging some 1.4 million ha of forests - 43,000 ha of which being completely destroyed - and causing windfalls totalling some 8 to 10 million m^3 of timber (Chirici *et al.*, 2018) as well as having many other direct and indirect impacts on alpine areas. Besides damaging forest resources in environmental terms, indeed, windstorms like Vaia have also socio-economic impacts, affecting (among others) timber supplies, market prices, management/investment choices and cost of insurance, not mentioning damage costs, and losses of human life and public goods like many ecosystem services provided by forests. However, while extreme weather events and natural disasters are perceived among the most likely and impacting global risks (World Economic Forum, 2018) their socio-economic dimensions and implications are still poorly addressed by research (Jahn, 2015). The responses and resilience dynamics that occur within and outside complex and fragile socio-ecological systems affected by windstorms are still poorly investigated and remain largely unknown, especially with regard to short-medium and long terms socio-economic and institutional effects of windstorms. In the case of Vaia, for instance, public and private actors across and within affected regions and autonomous provinces in Northern Italy had different reactions, resulting in a high number of fragmented and not/poorly coordinated initiatives, e.g. in the removing and marketing of damaged timber, data collection and communication, funding interventions, proposing restoration measures, cross-sector coordination for the post-event interventions etc.

Building on above-reported considerations, this paper aims at partially filling-in these research and knowledge gaps, by: (i) reviewing existing literature on windstorms affecting forests in Europe, with a specific focus on their socio-economic impacts; (ii) identifying and analysing the main Vaia socio-economic impacts in affected regions and autonomous provinces; (iii) investigating the possible cause-effects linkages identifiable along forest-based "value chains" in fragile rural areas, focusing on social, economic and institutional/governance issues; and (iv) building on previous points, identifying the weaknesses to be solved and the strengths to be reinforced for developing appropriate strategies to increase resilience of territories exposed to windstorm risks. Findings will be summarized and presented under the form of lessons learnt to inform future policy making in support of adaptive strategies and resilience-oriented initiatives.

Figure 1: Main windstorm events occurred in the past in European countries (above) and Italy (below)



Source: modified from ERSAF, 2019.

2. DATA AND RESEARCH METHODOLOGY

Data and research methodology consist of three main steps described below.

2.1. Preliminary literature review

A preliminary literature review has been performed to identify and analyse existing scientific and grey literature dealing with socio-economic and institutional impacts of extreme events and nature disasters affecting forest resources, with a focus on windstorms and the European context. We took advantage of databases like the Extreme Wind Storms Catalogue, review studies like those by Gardiner *et al*. (2010 and 2013), Stucki *et al*. (2014) and Gregow *et al*. (2017), and additional literature retrieved from international scientific literature databases and other sources.

2.2. Socio-economic impact assessment

Collection of data on socio-economic impacts of Vaia storm has been performed through a mixed desk- and field-based approach implementing the following actions: i.e. (i) review of existing scientific and grey literature, with special reference to official reports by local public authorities, secondary data on damages and cost estimation from grey literature, databases and other technical documents; and (ii) focus groups/interviews with key public and private stakeholders. As for the latter, it has not been possible to perform them so far, due to restrictions imposed by Covid-19 emergency, however they will be rescheduled in the next months. At this stage, pre- and post-Vaia data have been collected and analysed in order to identify potential impacts of the storm on the timber market, in terms of price-patterns, number/size of lots placed on the market, types of assortments, number and origin (e.g. local/non-local) of auction participants, etc. Data on timber auctions and sales within a selection of the affected areas have been collected through public accessible sources (e.g. online databases such as the "*Portale Legno Trentino*" and specialized online timber-trade portals), this information will be complemented by contacting bodies in charge of managing auction and sale procedures. An important aspect to bear in mind is that, due the fact that forest cleaning operations in some regions is not yet completed, it is difficult have a clear estimate of the total forest loss and consequently it is not possible to have a clear picture of related impacts in the wood market (Provincia Autonoma di Trento , 2019).

2.3. Conceptualization and visualization of cause-effects

A preliminary qualitative conceptualization and graphic visualization of the cause-effects, as derived from the analysis of accessible literature and lessons learned from other European cases, has been drafted and will be finalized in the next months. The expected final outcome is a causal map showing cause-effect interconnections among different sectors hit by windstorms in Europe. The identification and visualization of these dynamics is a preliminary step aimed to acquire a better understanding of windstorm impacts and damages within different socio-economic and institutional domains. Besides identifying direct windstorm effects, the adopted methodological approach can allow assessing possible spillovers and indirect impacts on multiple social and ecological dimensions. By focusing on the interactions among different dimensions of forest socio-ecological systems, the causal map will allow investigating potentialities for designing and implementing a systemic approach in post-windstorm strategy development for the recovery of forest-based communities. This approach represents the starting point for the identification of the weaknesses to be solved and the strengths to be reinforced for developing appropriate strategies aimed to increase the resilience of territories prone to windstorms. It is also aimed to valuing environmental resources as well as human and social capital, while improving governance at various levels. Indeed, a governance structure able to create links and synergies among different actors and initiatives will likely boost community resilience, strengthening the engagement and adaptive capacity of every single actor and ultimately determining positive effects also on forest resources.

3. RESULTS

Preliminary results presented at this stage of the research refer to the review of existing literature on windstorms affecting forests in Europe (3.1), paying special attention to socio-economic impacts (3.2), and the assessment of specific impacts of Vaia storm on forest-based value chains and markets, with a specific focus on the wood market (3.3). Additional results will be available in the next months.

3.1 Windstorm cause-effects linkages and effects categorization

The literature review has focused on European forests and windstorm damages related to socio-economic and institutional aspects. A search performed via Scopus has allowed preliminarily identifying 386 papers that have then been carefully screened and analysed. At this stage only 20 (i.e. 5%) papers analysing socio-economic and institutional impacts have been identified. The limited number of papers is already per se an early evidence of poor attention on socio-economic, institutional and cultural impacts of windstorms. At the same time the review highlighted how these aspects are strongly interlinked with ecological, environmental and technical ones. Indeed, all papers analysed reported recovery strategies regarding ecological and technical dimensions that are expected to be influenced/constrained by economic, institutional or managerial aspects, such as for example the normative framework or decision-making processes. On the other hand, windstorm impacts on environmental domains can have several indirect and spillover effects on socio-economic dimensions. For example, changes in the forest composition due to wind damages have not only consequences at ecological level, by modifying forest biodiversity and regulatory services, but also on tree productivity, thus impacting the wood market and forest owners' income (Reyer *et al*., 2017). Similarly forest management decisions have consequences not only on environmental resources, but also on the wood market, producing different effects according to the spatial dimension considered (Andersson *et al*., 2018). At the same time, modifications of the forest structure affect the forest landscape value and community sense of place (Gardiner et al., 2013; Kulakowski *et al*., 2017).

By highlighting cause-effects linkages among all components of forest socio-ecological systems, the review allowed identifying and preliminarily classifying social and institutional costs of shortages or modifications in forest ecosystem services and emphasizing how socio-economic domains are embedded in all the other sectors. A preliminary summary of the most relevant socio-economic and institutional dimensions and related effects produced by windstorms, as identified via the literature review, is reported in Table 1. The list is not complete yet as categorisation and elaborations are still ongoing and will be finalised in the next months. Within Table 1, *dimensions* refer to the most relevant socio-economic dimensions identified via the literature review. Within each dimension several specific windstorm effects and consequences have been categorized, however, in order to facilitate the visualization and understanding of the table, single impacts have not been reported, rather they have been grouped into *macro-categories* and *sub-categories* they belong to. *Macro-categories* refer to specific thematic subsets connected with a certain socio-economic or institutional dimension and can be further distinguished into sub-categories. Each *sub-category* identifies a cluster of windstorm effects related to a specific sector or stakeholder group.

Table 1. Summary of key socio-economic and institutional dimensions and related macro- and sub-categories of effects by windstorms

Dimensions	Effects	
	Macro-categories	Sub-categories
Institutional	Role of institutions	1) Changes in state subsidies 2) Changes in technical assistance 3) Changes in public forestry operations 4) Changes in policy and legislation for forest/ landscape management 5) Changes in legislation 6) Changes in institutional and governance dynamics
Social/cultural	Forest cultural ecosystem services	1) Changes in recreational activities 2) Changes in tourism sector 3) Changes in landscape
	Consequences on interactions among stakeholders	1) Changes in relations within the forest sector stakeholders 2) Changes in relations within stakeholders involved in forestry operations 3) Changes in relations within private forest owners and institutions 4) Changes in relations among private forest owners
Economic	Wood market and prices	1) Changes in log prices 2) Changes in raw material disposability 3) Changes in wood market
	Consequences on income	1) Changes in forest owners' income 2) Changes in forest-related industries income 3) Changes in income deriving from the cultural and recreational services

Source: own elaboration

The preliminary analysis conducted so far allowed highlighting differences with regard to the relevance of the various dimensions taken into account as well as the level of analysis for each of them.

With reference to the *institutional dimension*, all publications addressing subsidies and institutional programmes adopted after windstorms focus on strategies related to the recovery of the forest-based value chains, leaving aside the development and reconstruction of other sectors that might have a role for community resilience, such as infrastructure and energy sectors or primary and secondary industries (e.g. dairy products, tourism, etc.).

This is indirectly confirmed when considering the *economic dimension*: the main effects identified are those related to changes in the wood market and in forest owners' and stakeholders' income, while consequences on tourism or other cultural services are scarcely mentioned. While 14 out of 20 papers deal with economic effects, only 3 of them consider sectors and value chains different from the wood one, namely the tourism sector or other cultural and recreational services.

Finally, with regard to *social and cultural dimension*, literature focuses mostly on relations among stakeholders and actors connected to the forest sector. The strategies and role of community members in ensuring and boosting community resilience at broader level seem to have been less investigated: among the 11 papers addressing windstorm consequences at social level, only 3 considered interactions at community level and changes in local population's wellbeing due to storms.

To summarise, the preliminary literature review round highlighted that, despite the variety of social and cultural aspects potentially affected by windstorms, existing scientific literature mainly concentrates on forest-based value chains, forest-related industries and their stakeholders, while other dimensions underpinning community sustainability seem to have been poorly investigated so far.

3.2 Socio-economic impacts of windstorms in Europe: a preliminary overview

A preliminary assessment of existing literature on large windstorms in Europe allowed identifying more than 130 events affecting forest resources between 1950 and 2010 (Gardiner *et al*., 2010). The Extreme Wind Storms Catalogue that for the 1979-2012 period reports 23 high insurance loss storms and 27 high severity non insurance loss storms. Long-term forest loss due to windstorms have been published for Sweden (77 events in 1901–2000) (Nilsson, 2004) and Switzerland, where Stucki *et al*. (2014) catalogued approximately 240 high impact windstorms since 1859.

Data on socio-economic impacts associated to windstorms are scattered and unevenly available, both in terms of scope and methodological approaches. Data on total economic losses and overall storm damages are not available for all events, moreover information regarding minor storms are largely lacking. Indeed, existing literature focuses mainly on major storms and severely catastrophic events, living aside storms that hit small areas or with a moderate wind speed, despite the fact that they may have relevant impacts at a local scale (Schelhaas *et al.,* 2003). Gardiner *et al.* (2010) reported more than €15billion (bn) losses due to 13 out of 51 most damaging events between 1951 and 2010. According to estimations performed by the insurance industry, total insured loss from December 1999 storms Anatol (€2.2bn), Lothar (€6bn) and Martin (€2.6bn) totalled about €10bn across Europe. Total estimated economic losses where even higher, totalling €14.4bn. In 1990 a series of storms –Daria, Vivian, Wiebke, and five others– hit western Europe with a total insured loss of about €9bn (1990 values) (Munich Re, 2002). More than 2,500 casualties were reported for 11 selected intensive storms (Gardiner *et al*., 2010).

As for forest damages, Gardiner *et al.* (2010) and Gregow *et al.* (2017) reported windstorms caused a 960 million (mln) m^3 wood primary damage in 60 years. This corresponds to 0.12% of the standing volume of European forests being damaged annually, equivalent to about 38 mln m^3/year (Schuck and Schelass, 2013). Windthrown volumes affect timber markets and prices: after damaging storms, roundwood prices are generally much lower than in normal conditions due to (among other issues) higher harvesting and logistic costs, lower roundwood quality and the consequences of an excess supply. However, how windstorms impact on log prices strongly depends on the specific market conditions. For instance, roundwood stumpage prices tend to decrease more than roadside prices due to the general increase in harvesting and forestry operation costs and as consequence of several organizational and managerial problems along the wood chain (Gardiner *et al*., 2010; Schwarzbauer and Rauch, 2013; Riguelle *et al*., 2015). Storms can also have considerable impacts on the wood market in the long term: for example, after Lothar storm in France the amount of stored beech depressed the market for a number of years (Birot *et al*., 2009), and in Germany negatively affected Norway spruce prices for more than 10 years (Hanewinkel and Peiron, 2013). The severity of windstorm consequences on wood markets and forest related industries is deeply connected with stakeholders' and industry adaptive capacities. Technological innovation and specialization, especially for what concerns wood harvesting, storing, transportation and processing, allow to partially overcome the decrease in revenues via the optimization of the operations, preventing from a further decrease in wood quality and prices (Hartebrodt, 2004; Riguelle *et al*., 2015). Indeed, despite having several negative

implications, windstorms could introduce/induce some positive impacts and innovations in forest related industries, thus fastening change. Fouqueray *et al*. (2020) argue that the majority of forestry evolution in France were implemented starting from 1999, after Lothar windstorm. A similar increase in technological investments and forest equipment was recorded also by Hartebrodt (2004) after major storms that affected Germany in 1990 and 1999. The urgency of enhancing wood processing efficiency and minimizing costs of forestry operations after storms lead to progresses in forestry industries and amelioration of forest infrastructures (Gardiner *et al*., 2013). The need to identify strategies to minimize damages and income loss has led to a series of innovations: technology and market structure have been modified by disruptive changes generated by consequences of a catastrophic natural event. The Schumpeterian idea of "innovative destruction" seems to be at play behind such changes (Diamond and Arthur, 2006).

Besides technological improvements and technical innovations, institutional support and governmental strategies implemented during post windstorm management are key to mitigate storm impacts on forest value chains. National and regional subsidies, compensation measures and specific technical assistance are policy tools/measures that allow minimizing windstorm impacts and ensure the recovery of the forest sector, especially with regard to small enterprises and private forest owners (Hartebrodt, 2004; Gardiner *et al*., 2013; Riguelle *et al.*, 2015; Andersson *et al*., 2018). Measures implemented by public authorities and guidelines provided for forest management operations can have considerable effects both in the short and in the long run. In the short term they can boost forest sector responsiveness, while at the same time setting the stage for future forest management and planning at public and private level (Andersson *et al.*, 2018; Deuffic and Ní Dhubháin, 2020; Fouqueray *et al*., 2020). In this regard, windstorms could have remarkable impacts on power relations among actors and governance dynamics within the forest sector. Several researches have highlighted how institutional responses to windstorms are decisive for influencing stakeholders' legitimation of public institution actions and their perceptions as well as acceptance of existing forest management rules (Andersson *et al*., 2018; Deuffic and Ní Dhubháin, 2020).

Besides primary damage, secondary damage is common, including saproxylic insects in wood, damage by blue stain fungus, and increased incidence of root rot in the affected forest area that might affect timber quality and prices (Schelhaas, 2008).

As for other forest-based ecosystem services, storm damage to European forests could result in an annual reduction of 2% in the carbon sequestration by forests. This figure could exceed 5% by the end of the century if the growing stock continues to increase (Gardiner *et al*., 2010). On the other hand, storms can also produce positive impacts on ecosystems and ecosystem services. For example, the reduction in forest canopy and the increase in deadwood may positively affect forest biodiversity. In the short term, natural disturbances lead to a proliferation of certain forest flora and fauna components, increasing the diversity of animals and plants species. The increase in biodiversity introduces complexity in forests that have suffered from a standardization of forest species due to intensive use of forest for economic and productive reasons (Kulakowski *et al.*, 2017).

3.3 Assessment of specific impacts of Vaia storm on forest-based value chains and markets: preliminary results for the wood market

The assessment of timber trade data on pre- and post-Vaia timber sales via different sources shows that the increase in the supply of timber after the storm created market saturation conditions. For instance, in the case of the Autonomous Province of Trento, the volume of timber placed on the market within 3 months

after Vaia equalled the amount of timber normally placed on the market on yearly basis. The increase in sales continued even after early 2019: the total volume of timber sold via roadside timber sales reached 850,000 m^3, while the overall volume marketed from November 2018 until December 2019 - including both roadside and stumpage sales - accounts for 2,377,000 m^3, i.e. 59% of the windfall timber within the Autonomous Province of Trento (Provincia Autonoma di Trento, 2019). Market saturation is not without consequences: it reflects on a decreasing trend of sale prices for industrial logs that diminished from an average pre-Vaia value of about 80€/m^3 to 10-25€/m^3 few weeks after the storm. Few months after the storm sale prices returned to increase, but far from reaching pre-Vaia timber value: the average value - considering both stumpage and roadside prices – amounts to 40-45 €/m^3. Effects on prices are much more evident on sales of standing trees (stumpage prices), rather than roadside timber, due to higher costs and risks associated to harvesting and skidding operations. The downturn in prices is associated to the increase in the number of timber auctions with no bids, which reflects on the decreasing number of logging operators actively participating to auctions. Limited participation is linked, among other things, to the fact that in the first semester of 2019 large single auction-lots (10,000 m^3 or higher) were auctioned and many potentially interested buyers could not take the financial risks associated to them. Starting from the second semester of 2019, average lot volumes and number of sales got back to close-to-ordinary (i.e. *ex-ante*) conditions. However, roadside sale volumes strongly fluctuate in respect to pre-Vaia conditions and this has determined a constant price drop until reaching 18 €/m^3 for an average of 1500 m^3 per lot.

The increase in timber supply poses additional problems in terms of processing capacity by local sawmills: although the primary processing industry performs differently across regions and autonomous provinces in the north-east of Italy, it can be assumed local sawmills are not able to process such an amount of timber in the short-medium term. The ultimate consequence is the need to export towards traditional (Austria) and new (China) markets a large proportion of the harvested timber at low prices, losing the added value potential associated to the processing of low-cost raw material in the local territory. These trends are even more emphasised by the fact that huge volumes of damaged wood are marketed also on other European countries – almost 70 mln m^3 in Germany[1] and 10 mln m^3 in Austria in 2019 – thus contributing to market saturation and price depression. This had also implications for the global markets: in 2019 Europe became the second largest softwood log exporter towards China (Wood Resources International LLC, 2020).

Given the magnitude of the storm, post-event management has been posing severe challenges, including those regarding harvesting and removing of damaged timber. Technical, logistic and safety issues associated to mobilization of savage logs requested specialized machinery, equipment, training and skills that are not common for local forest enterprises. Combined with financial risk requirements due to large lots auctioned, this finally resulted in many cases into the need to hire specialised forest enterprises form outside (mainly form Eastern European and Baltic countries) creating some conflicts with local enterprises. In some cases, challenges posed by steep slopes and other extreme site-conditions associated with negative stumpage prices resulted in timber not being removed, thus creating potential risks in terms of pests.

[1] Windstorms, wildfires and pests have been reported to hit some 245,000 ha of forests in Germany, damaging some 160 mln m^3 of wood.

3. 4. CONCLUSIONS

This paper presents the preliminary results of a research aiming to address windstorm impacts on forest-based socio-ecological systems and in particular on their socio-economic dimensions. So far literature review has confirmed a deep research gap regarding windstorm impacts on socio-economic and institutional dimensions and a general tendency to a mono-sectorial approach in the investigation of storm-related issues. Indeed, most of papers analysed so far focus on windstorms consequences just from an environmental and technical perspective, paying no (or very little) attention to effects on socio-economic and governance aspects as well as to cross-sectoral and dimensional causal effects and relationships. In a similar manner, the limited existing literature addressing windstorm consequences on socio-economic, institutional and governance dimensions is solely focused on forest-related industries and their stakeholders, paying poor attention to storms impacts on other sectors and forest functions/services. All these findings seem to be in contrast with the complex network of cause-effects linkages among multiple sectors possibly affected by windstorms as emerged by a preliminary analysis and visual representation. According to this, impacts on environmental and technical dimensions affect socio-economic and institutional ones and vice-versa. Moreover, the nature, intensity and direction (i.e. positive/negative, increase/decrease, etc.) of impacts can vary depending on multiple variables, including (but not limited to) scale and time span, turning their management quite challenging. The poorly cross-sectoral and cross-dimensional nature of existing literature is likely to limit a broader knowledge and deeper understanding of complex extreme events like windstorms and their impacts on socio-ecologic systems. At the same time such a fragmented and segregative view/approach may result in uncoordinated and less effective post-event strategies.

By missing to detect and understand the complexity of cross-sectoral/dimensional cause-effect interlinkages that are at play behind extreme events like windstorms we run the risk to miss opportunities to contribute informing future policy initiatives in this field, the development of effective strategies to cope with climate change and extreme weather events in the future and finally to develop appropriate solutions to enhance the resilience of socio-ecological systems.

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