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A Rapid Assessment of the Economic Impact of the Central European Flood 2024 on Austria

ASCII Research Brief

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Abstract
Between 14 and 21 September, Storm Boris brought heavy rain and flooding to Central Europe. Such extreme weather events will become more frequent and, above all, more intense as a result of climate change. It is therefore important to develop methods to rapidly assess the economic impact in order to tailor measures to mitigate losses. This Research Brief estimates the economic losses to be around EUR 1.3 billion. This includes private households, damaged inventories and capital stocks, and interruptions of firms' operations. Infrastructure is not included, however. Austria appeared to be relatively well prepared. Despite the magnitude of the flood, more severe economic damage was prevented. Nevertheless, the current compensation model can be improved.

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Rapid Assessment of the Economic Impact of the Central European Flood 2024 on Austria

1. Introduction

The Central European Flood caused by storm Boris consisted of a series of floods that occurred between 14 and 21 September 2024. Heavy rainfalls for four days in a row affected parts of Austria, Czechia, Romania, Slovakia, and Poland. The rainfall was caused by a weather phenomenon in which cold air from the polar region met warm and humid air from Southern Europe. While there is no robust statistical evidence that such depressions (known as Vb depressions) are becoming more frequent because of human-induced climate change, it is well established that their intensity is getting stronger.[1] The intensity of these and likelihood of similar extreme events will therefore continue to increase in the future, as will their direct and indirect economic impacts. Rapid assessment tools and models are therefore needed to understand as fast as possible whether such events have a significant economic impact, so that appropriate responses can be put in place.

This Research Brief discusses economic losses of producing sectors. For the total cost estimates, it also draws on estimates of insurance companies to include damages of private households. Apart of direct losses, companies affected by such floods are embedded in regional and international value chains, along which disruptions can spread to companies in industries and regions other than those directly affected. This is quantified and operationalised by the concept of systemic risk in production networks, which refers to the likelihood that an initially localised event (such as a flood) will lead to measurable economy-wide impacts.[2] A growing body of research has established the existence of tipping points in systemic risk.[3] While production networks can absorb disruptive events to a certain extent, there are clearly defined tipping points beyond which it becomes increasingly likely that neuralgic points in the network will be affected, causing significant damage to the entire network.[4] The question is at what point do floods become such systemic events and whether the recent Central European Flood of 2024 qualifies as such an event.

1.1. Cost estimates

Estimates of the damages caused by the flood are already available. The Association of Austrian Insurers (Versicherungsverband Österreich, VVÖ) has already estimated losses of this event up to €700 million. This includes mainly damage to households and the

[1] https://www.worldweatherattribution.org/climate-change-and-high-exposure-increased-costs-and-disruption-to-lives-and-livelihoods-from-flooding-associated-with-exceptionally-heavy-rainfall-in-central-europe/, accessed September 25, 2024.
[2] Diem, Christian, et al. "Quantifying firm-level economic systemic risk from nation-wide supply networks." *Scientific reports* 12.1 (2022): 7719.
[3] Renn, Ortwin, et al. "Systemic risks from different perspectives." *Risk analysis* 42.9 (2022): 1902-1920.
[4] Inoue, Hiroyasu, and Yasuyuki Todo. "Firm-level propagation of shocks through supply-chain networks." *Nature Sustainability* 2.9 (2019): 841-847.

residential sector and to a lesser extent firms' capital stocks.[5] The Austrian Hail Insurance (Österreichische Hagelversicherung, VaG) estimated losses in the agricultural sector of around €10 million.[6] The floods have also caused extensive damage to the railway infrastructure, which will slow and delay passenger and freight transport for months. However, it is not yet clear to what extent these estimates will translate into economic impacts beyond infrastructure damage. Businesses are affected on several levels, including damaged stock and business interruptions, which in turn can lead to disruption of supply to other companies not directly affected by the flood.

1.2. Objectives

In this research brief, we conduct a rapid assessment of the production related economic impact of flooding in the most affected areas in Austria, which are in the federal state of Lower Austria. An input-output model estimates the effects for manufacturing and services. The impact on the primary sector is assessed separately. We conclude with a general discussion and draw some policy implications. The results can also be accessed in an online dashboard. [7]

The perspective taken has some limitations with regard to the losses covered. We focus on the production side of the economy. It is assumed that the insurance estimates presented below covers private households and firms' lost capital stock. Damaged public infrastructure is not included. Also, indirect effects (e.g., workforce not being able to reach the workplace on time) and production that is not covered in GDP figures (e.g., voluntary work) are not included.

2. Impact assessment

The Gross Domestic Product (GDP), the key economic performance indicator, is a flow concept. Hence, damaged capital stocks are not captured by the indicator. On the contrary, re-establishing capital stocks leads to higher investments, which have a GDP increasing effect. This effect is expected to be moderate. Total investments in Austria amounted to approximately 88 billion euros. Assuming all damages, i.e. EUR 700 million, to be fully repaired would increase gross investments by 0.8%. It is likely that this growth impulse will spread over a longer period. Assuming a reconstruction period of two years, the impetus would be reduced to a magnitude that is within the revisions of the official investment figures of the national accounts by Statistics Austria.

2.1. How does the economic model work?

There are negative, indirect effects such as down times of manufacturing firms or closed transport routes. This leads to the question about the wider economic effects. Hence, an input-output model was used to model the effects on the regional economy. The underlying data uses information about the private sector. Households are not included.

[5] https://www.vvo.at/presse-artikel/hochwasseroesterreichische-versicherer-befuerchten-rekordschadensumme-von-600-700-mio-euro/, accessed September 25, 2024.
[6] https://www.hagel.at/presseaussendungen/jahrhunderthochwasser/, accessed September 25, 2024.
[7] https://ascii.ac.at/news/flooding-in-austria-interactive-map/, accessed October 8, 2024.

First, we modelled flooded areas by overlaying flood risk zones[8] with reports from 112 municipalities in Lower Austria and identified companies located in these areas by combining information from OpenStreetMap (https://www.openstreetmap.org) with commercial business intelligence datasets (https://orbis.bvdinfo.com). Based on their sector classification, firm size, and modelled exposure to flooding, we estimated direct economic losses through restoration times and inventory damage. The duration of business interruption by sector was estimated using reference tables from the FEMA's HAZUS model.[9] Indirect economic losses were then estimated using an input-output model with inventory replenishment as well as forward and backward propagation.[10],[11]

Municipalities in Lower Austria were classified as not affected at all, moderately affected (isolated reports of flooding) or severely affected (complete flooding of large areas). For the moderately or severely affected areas, standardized risk zones were identified based on a model of a 30-year and 100-year flood, respectively, along with the businesses located within them, see Figure 1.

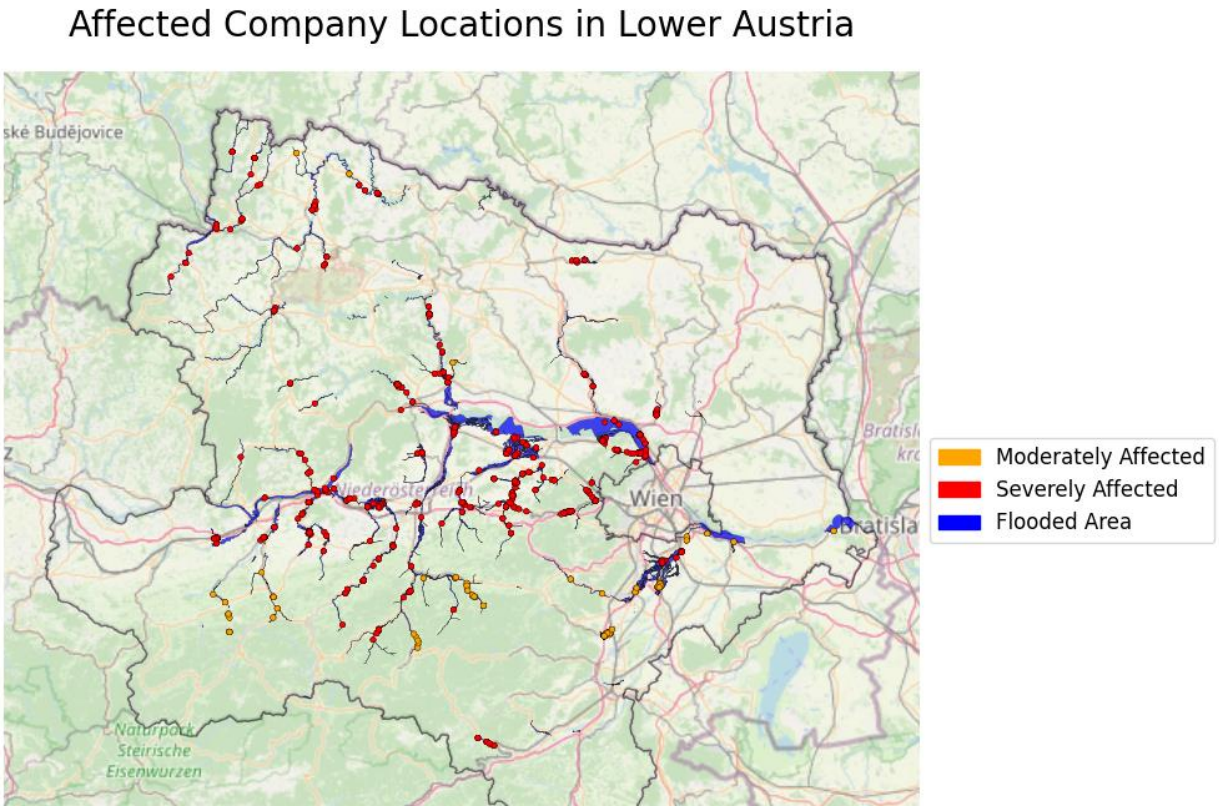

Figure 1. Modelled flooded areas (blue) and locations of moderately (orange) or severely (red) affected companies.

[8] https://maps.wisa.bml.gv.at/gefahren-und-risikokarten-zweiter-zyklus?g_card=hwrisiko_gefahren_ueff#, accessed September 25, 2024
[9] Scawthorn, Charles, et al. "HAZUS-MH flood loss estimation methodology. I: overview and flood hazard characterization." *Natural hazards review* 7.2 (2006): 60-71.
[10] Hallegatte, Stéphane. "An adaptive regional input-output model and its application to the assessment of the economic cost of Katrina." *Risk Analysis: An International Journal* 28.3 (2008): 779-799.
[11] In the model we further assumed no changes in demand.

2.2. Impact assessment

In total, we have identified 841 companies, 676 of which being severely affected. Out of these, 68 companies have reported ten or more employees. Figure 2 shows the distribution of these companies by district and size. Most of the affected companies are in Sankt Pölten, Tulln, and Melk. The number of persons employed in these companies, broken down by sector, is shown in Figure 3. The largest contributing sectors are fabricated metal products, and machinery. Furthermore, only a few companies with more than hundred employees were affected.

To model direct economic losses, we consider losses due to business interruption (e.g., time during which the firm is unable to operate due to cleaning, replacement of damaged equipment) and inventory losses (i.e. production inputs were damaged during the flood and need to be replenished). These losses are aggregated at the sectoral and national levels and used as supply shocks in an input-output model. The model estimates the losses incurred by other sectors and firms that lose some of their inputs, which in turn negatively affects their output etc. Inventories also act as a buffer for the supply chain propagation.

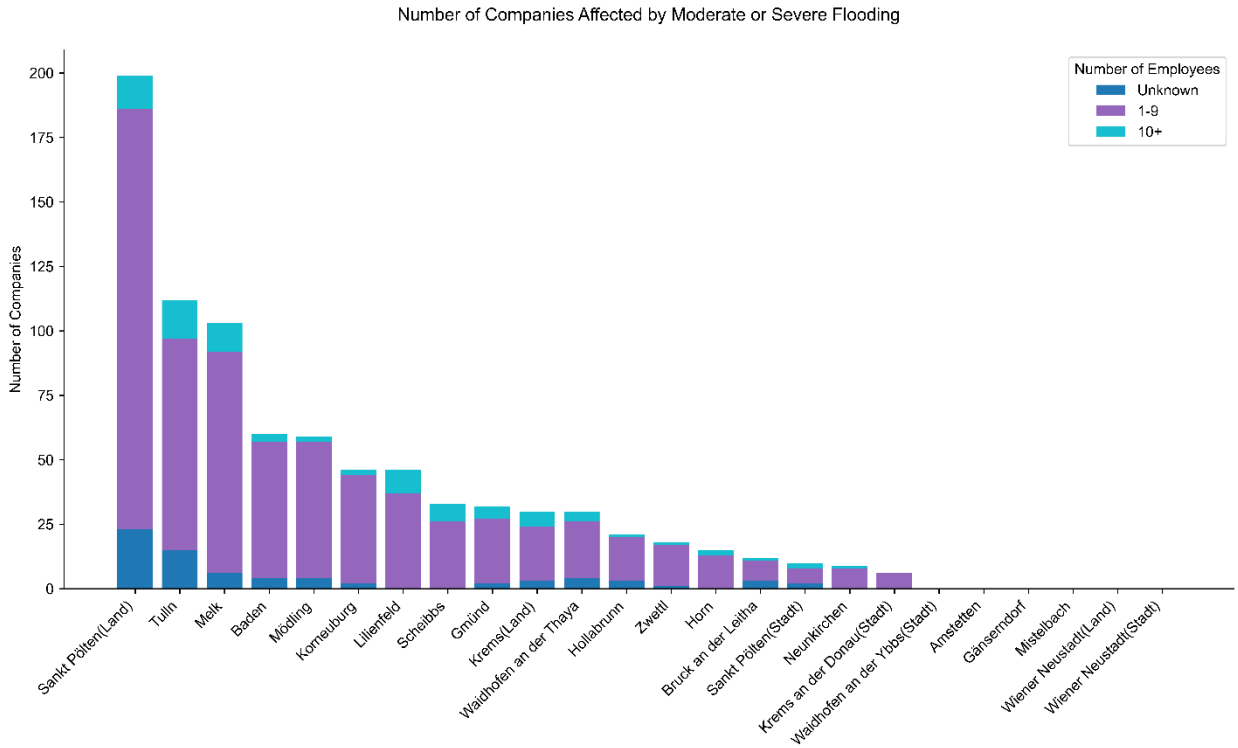

Figure 2: Distribution of companies across flooded regions.

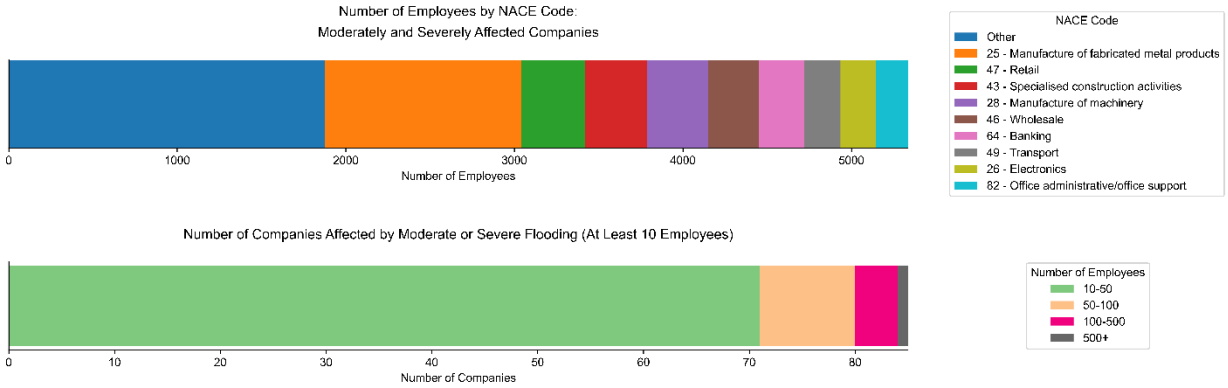

Figure 3: Number of employees of affected companies by economic sector across all regions (top) and the number of affected companies by size including only companies with ten or more employees.

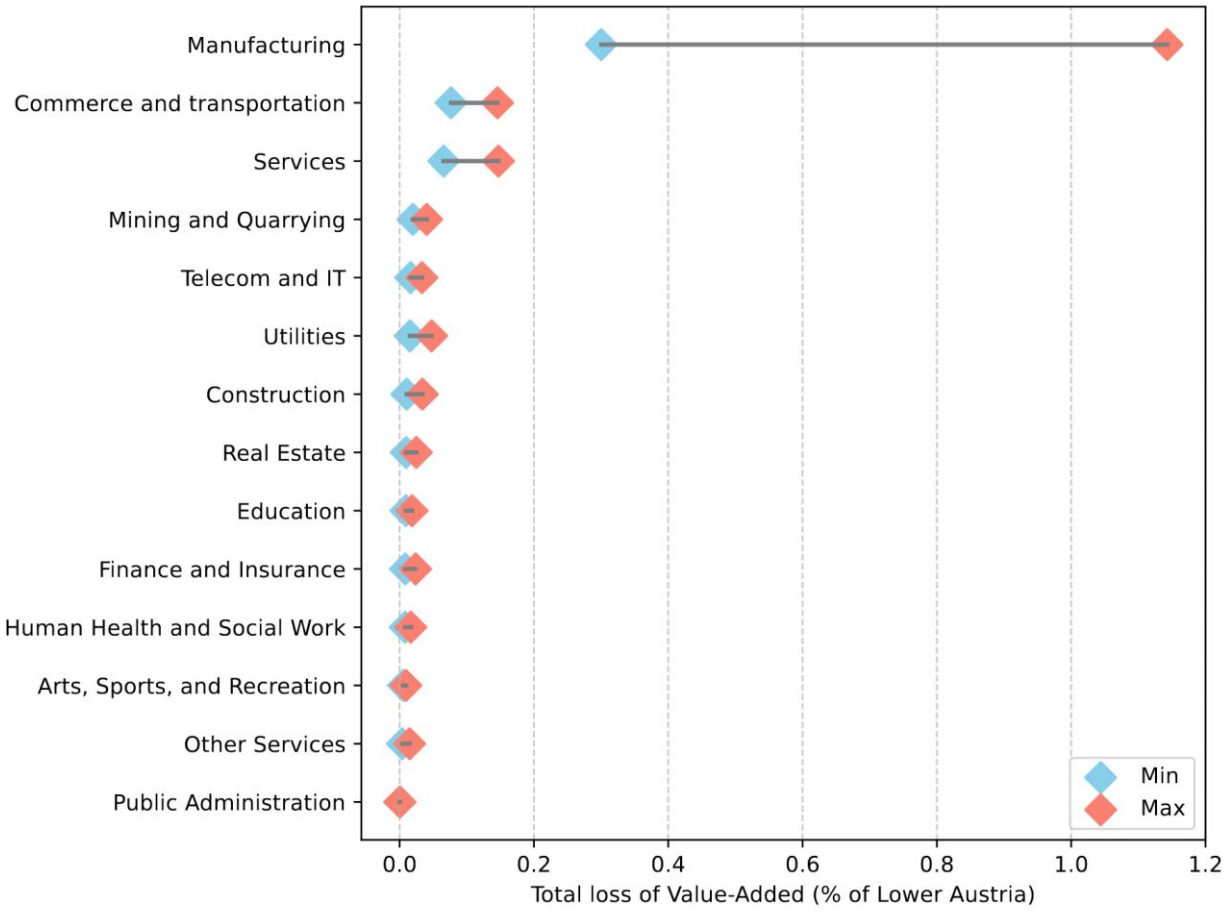

Figure 4: Total losses by sector relative to total value added in Lower Austria.

Upper and lower bounds for the estimates of the total economic losses are created by taking the minimal and maximal restoration times according to the FEMA reference tables, which range from one month to a full year.

Based on these assumptions, we estimate total losses of production in Austria between EUR 300 and 900 million or between 0.03% and 0.11% of annual production. Note that direct losses typically make up 75% of total losses in the sector. A sectoral breakdown of these total losses relative to the total value added in Lower Austria is shown in Figure 4.

They concentrate mostly on the manufacturing sector, where they range between 0.3% and 1.2% of total value added in Lower Austria for comparison. The reference year is 2020.

2.3. Summary of the input-output modelling

It is already clear that the floods have caused significant damage to housing and transport infrastructure. In our rapid assessment, we estimate these losses to be in the range of EUR 300 to 900 million. While these figures signal potentially catastrophic losses for individual companies, they are small in relation to Austria's total annual value added, of which they account for 0.03 to 0.09%.

Therefore, based on what is currently known about the impact of the flood, it is highly unlikely that the flood will have a major impact on Austria's GDP. However, the effects are strongly concentrated regionally. The effect on the regional value-added amounts to approximately 0.55% to 1.7%. Note that these results are conservative in terms of the number of companies potentially affected. Companies are still reporting their losses, which could further increase the economic losses. This rapid assessment will be updated as more complete data become available.

The upper and lower limits of these estimates are due to uncertainties in recovery times. While in some cases it may take no more than a few days to restore even severely flooded businesses, this may not always be the case. For example, businesses may be critically dependent on access to a particular railway station. However, it now appears that rail logistics will be disrupted for months because of the flooding, leading to much longer recovery times and the upper limits of our estimates.

3. Agriculture

Agriculture is particularly exposed to natural hazards, especially those related to weather conditions: frost, drought, hail, heavy rain, and flooding. The floods in September 2024 along river systems flowing into the Danube are thus only part of the damage that agricultural crops have faced throughout the year 2024. In addition, agriculture plays a crucial role in flood management. Since the land is not sealed, it can absorb large amounts of water up to a certain threshold, significantly contributing to reducing runoff. Agricultural areas are often located in retention zones and are thus deliberately integrated into risk management strategies. The flooding of such areas is intentional and helps protect or at least relieve downstream zones.[12]

The extensive flooding of agricultural crops has therefore significantly contributed to damage reduction. The societal benefit of this function cannot be quantified here. Evaluations of event documentation must be conducted, where detailed models can be used for corresponding investigations.

[12] Grüneis, H., J. Niedermayr, K. Schroll, K. Wagner, 2023, Die Landwirtschaft im integrierten Hochwasserrisikomanagement. Studie der Bundesanstalt für Agrarwirtschaft und Bergbauernfragen, Wien.

3.1. Estimated Damages in Agriculture

Estimates from the Austrian Hail Insurance (2024) put the insured damage at 10 million euros.[13] These figures are reliable. They are based on insurance contracts and a widely distributed network of knowledgeable individuals who can accurately assess the type and extent of the damage. Not all agricultural crops are insured against flooding. Additionally, insured farmers must bear part of the damage themselves in the form of a deductible. Therefore, the amount mentioned above represents a lower bound of the total damage of agricultural crop production.

To determine the overall extent of the damage, as well as the spatial distribution and distribution among crop types, a damage assessment was carried out, consisting of the following steps:

- The flooded areas were researched by ASCII based on a 100-year flood model and used as shapefiles for the geoinformation analysis.
- The areas used for agriculture were obtained from INSPIRE (https://agraratlas.inspire.gv.at/).
- The overlay of the two geographic maps provides a table showing which crops were severely, moderately, or not affected by the flooding.
- The severely affected areas of each crop were classified as "damaged" and included in further damage assessment.
- Based on calculations of standard outputs (see Table 4.9.8 of the Green Report 2024; see www.gruener-bericht.at) and using current producer prices for those crops for which such data is available (see preise.agrarforschung.at), the potential damage value of a total loss was determined.

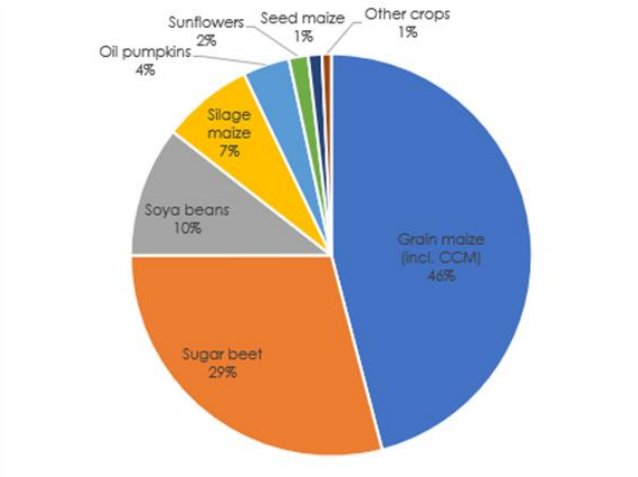

Figure 5: Distribution of agricultural damage by crop type (Source: WIFO).

Only those crops that were likely not yet harvested at the time when the damage occurred (see Figure 5). For example, cereals were no longer in the fields and thus could not be damaged. Although maize, soybeans, and pumpkins were likely partially harvested, the

[13] See https://www.hagel.at/presseaussendungen/jahrhunderthochwasser/ (accessed on 30 September 2024).

damage estimate assumed a total loss. This is certainly applicable to pumpkins. Whether maize that was flooded can still be harvested will become clearer in due course. If the water level was not too high and the subsequent drainage allows for harvesting, the anticipated damage could be reduced (Figure 6 illustrates the regional impact). The maximum damage determined in this way is estimated at 14.7 million euros.

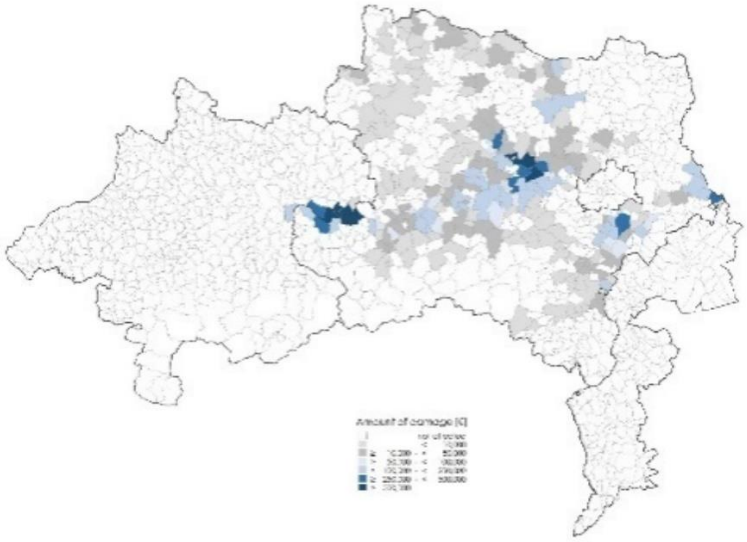

Figure 6. Regional impact in agriculture

These calculations do not account for crops grown for specific purposes, where penalties may be incurred if delivery does not occur. They also do not consider the consequences for processors who may now need to source raw materials from more distant locations, or if products with geographical indications were destroyed, whose value is higher than the values used here. Additionally, these calculations do not consider the benefits for downstream areas, where large agricultural fields were able to absorb water and thus significantly contributed to reducing runoff.

3.2. Summary of the effects on crop production

The damage to agriculture due to the flooding is likely to exceed 10 million euros. This is the estimate from the Austrian Hail Insurance for insured damages. According to our calculations, the extent could increase by up to 4.7 million euros when we consider all losses of crop production. However, it is possible that favourable conditions could reduce this amount.

4. Summary and conclusions

This research brief contributes to an estimate of the total damage that the storm in September 2024 has caused in Austria. Damages in private household amount to approximately EUR 600-700 million.[14] In addition, industry and manufacturing companies

[14] This figure is provided by the Associatoin of Austrian Insurers. The reported damages are predominantly in the household sector. It is assumed that firms' asset losses play a minor role in this figure.

suffered a loss between EUR 300 and 900 million, which is why we assume a mean of EUR 600 million. Losses in crop production amount to approximately EUR 15 million. In total, these damage categories amount to approximately EUR 1.3 billion. Currently, there is no information about infrastructure damages. These damages are geographically concentrated – see https://www.wifo.ac.at/institut/visualisierung/hochwasserschaeden/.

A recent publication finds that "mega-floods" in Europe could have been anticipated.[15] In 2024, Austria seemed well prepared, and the management of the crisis also worked impressively. The economic impacts presented in this brief suggests that it is unlikely that the flood will have a significant effect on the Austrian economy. Even though the flood was severe, the economic effects were moderate because flood prevention measures have been taken in the past. In recent years, Austria has been investing around EUR 60 million a year in flood protection, which significantly reduces current and future damage risks. Following the 2002 floods, which caused damage totalling EUR 3 billion, the impact of the 2013 floods was reduced to around EUR 0.9 billion thanks to improved measures such as alarm, emergency and damage minimisation systems, flood basins and dams.[16] In Austria, policy makers at all governance levels and the civil society have learned their lessons from previous devastating events with many casualties and invested significant resources and efforts in risk mitigation systems.

Yet, floods are becoming more likely and more intense, which leads to the question about the optimal policy mix. Currently, policies emphasise on mitigation instruments. Flood prevention measures such as renaturation and general reduction of CO_2-emissions provides scope for policy makers. In addition, the compensation mechanism for especially households seems suboptimal. Most damages are not generally insured, partly because the premiums for adequate protection would be unaffordable. This wrongly allocates risks, i.e. people settle in flood zones. As a result, most of those affected depend on their reserves, donations and emergency aid from the public disaster fund.[17]

The emergency aid from the state is fraught with problems. The victims act as "petitioners". The allocation is decided on an ad hoc basis and usually insufficient. It is disputed whether the injured parties have a legally enforceable claim from the fund. Hence, the compensation model should be improved. Compulsory insurance against natural disasters is more suitable than ad hoc state compensation. Professional insurers with established structures for claims settlement could cover for catastrophic events. They would lower risk premia by spreading them over a larger group. Victims would have enforceable claims from the outset. The insurance would also charge a higher premium to those who bear a higher risk (e.g., buildings in areas at risk), instead of making all taxpayers bear the burden indiscriminately after an event. Like in the case of the hail insurance, the state can also make a financial contribution where the premium volume is insufficient. One could also consider transferring at least part of the Austrian climate

[15] Bertola, Miriam, et al. "Megafloods in Europe can be anticipated from observations in hydrologically similar catchments." *Nature geoscience* 16.11 (2023): 982-988.
[16] See https://www.tuwien.at/tu-wien/aktuelles/news/news/das-september-hochwasser-was-lernen-wir-daraus (accessed on 30 September 2024).
[17] Sinabell, Franz; Url, Thomas. *Effizients Risikomanagement für Naturgefahren am Beispiel von Hochwasser*. WIFO Monographien Wien, 2007, online available at https://www.wifo.ac.at/wp-content/uploads/upload-6165/MB_2007_06_05_RISIKOMANAGEMENT.pdf.

bonus to a climate damage fund from which premiums are subsidised. Poorer households could also be given disproportionate support.[18]

[18] See https://www.derstandard.at/story/3000000237451/besser-versichern-als-auf-staatshilfen-hoffen (accessed on 30 September 2024).