

**CEDIM Forensic Disaster Analysis Group (FDA)**

**June 2013 flood in Central Europe - Focus Germany**  
**Report 2 — Update 1: Impact and management<sup>1</sup>**

(This report includes developments up to 20 Jun 2013 at 10:00 a.m.)

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Breached levee at Fischbeck (Photo from 10 Jun 2013), Stendal District, northern Saxony-Anhalt (Photo: Berns-Volker Brahms / Volksstimme)<sup>2</sup>

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<sup>1</sup>This report was published on 13 Jun 2013, revised on 17 Jun and updated on 27 Jun 2013.

<sup>2</sup>After a levee was breached at Fischbeck (Photo) in the north of Saxony-Anhalt, floodwaters from the Elbe have been flowing into the Elbe-Havel-Winkel since early Monday morning (10 Jun 2013). By 12 Jun, 6000 people in several areas had been evacuated; a total of 40 000 were evacuated in Saxony-Anhalt. The break in the breached levee can only be closed when the water levels are receding. In this photo, the water level was 8.20 meters — 52 centimeters above the last record from 2002. Reproduced with permission from the chief editorial staff at "Volksstimme" (Magdeburg/Stendal).

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<b>Short summary of the 2013 June floods</b>	
<b>Basic hydrometeorological information (see Report 1 — Update 2)</b>	
<b>Key areas affected</b>	Germany (Saxony-Anhalt, Saxony, Thuringia, Bavaria, Austria, Czech Republic; catchment area of the Danube (including the Regen, Lech, and Inn-Salzach) and the Elbe (including the Saale and the Mulde)
<b>Hydrological magnitude</b>	<p>Largest area affected of all flood events since 1950 (&gt;46 % of major rivers in Germany are affected by floods with at least a 5-years return period). Discharges and water levels in many areas in the catchment areas of the Danube and Elbe reached record values.</p> <p>Flood type: large scale river floods with rivers overflowing their banks and the danger of levees breaching and extensive flooding of the hinterland.</p>
<b>Preconditions and meteorological causes</b>	<p>Snow cover in high-altitude alpine mountains lasting till May. Extremely wet month of May, resulting in extensive oversaturation of the soil (greatest extent in the past 50 years), highly reduced infiltration capacity of the soil.</p> <p>Stable meteorological condition (TM) constantly brought moist air from South Eastern Europe northwards and from a northeastern direction to Central Europe. Situation was aggravated in areas of heavy rainfall in the Central Uplands and the Alps due to orographic forcing: Prolonged heavy precipitation in the Central Uplands and the areas close to the Alps.</p>
<b>Sources</b>	Own analyses, German Weather Service (DWD), wettergefahren-fruehwarnung.de, Hochwasserzentralen.de.
<b>Basic information on impact</b>	
<b>Death toll and persons affected by evacuations (as of 09 Jun 2013)</b>	<p>8 deaths in Germany to date (25 deaths in all affected countries)</p> <p>A minimum of 52 500 persons affected by evacuations along the Danube and Elbe</p>
<b>Disruptions in infrastructure (31 May to 04 Jun 2013)</b>	Obstruction of traffic on German federal and interstate highways due to floods in 89 state districts. In total, there was a minimum of 4866 h of obstructed traffic in the interregional transportation network.
<b>Potential damages</b>	<p>No model-based CEDIM estimates as yet; significant amount of damages in all important sectors is expected: residential buildings, business premises, infrastructure, agriculture; indirect damages due to the interruption of traffic and business; reconstruction costs; increase in flood protection budget; intangible costs (e.g. psychological impact)</p> <p>External estimates of total damages (Filch Rating, GDV): approx. € 12 billion;</p> <p>For Germany: flood relief funds amounting to € 8 billion</p>
<b>Resilience (based on socio-economic and institutional factors)</b>	High resilience along the Bavarian Danube, mid to high resilience along the Upper Rhine and Lower Elbe, low to mid resilience along the Lower Rhine, Elbe and Mulde.
<b>Preliminary estimate of impact (resilience, flood intensity)</b>	Moderate impact along Danube and Lech (most significant exception: the district of Deggendorf), low impact along the Rhine, high impact along the Elbe (calculations for Lower Elbe are preliminary, as the event has yet to reach its peak at these sections).

<b>Sources</b>	Independent analyses, Fitch Rating, German Insurance Association (GDV)
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## Summary

Starting on 31 May 2013, the development of a large-scale flood event began in Central Europe, which primarily affected Germany, but also its neighboring countries Austria, Switzerland, the Czech Republic and Poland, as well as Slovakia, Hungary, Croatia and Serbia.<sup>3</sup> The meteorological cause which ultimately triggered the floods was a stable general weather pattern in Central Europe ("Trough Central Europe" - TrM according to the German Weather Service classification scheme). A cut-off upper low pressure system over the European continent that was slowly shifting eastwards continuously supplied moist, unstable air of subtropical origin in a wide sweep over northern to central Europe on its eastern side, which precipitated in long periods of heavy rain, especially in areas of orographic uplift in the Alps and the Central Uplands. The extent of the floods was aggravated by the extreme and widespread saturation of the soil in the affected catchment areas, which resulted from a strong precipitation anomaly during the month of May.

The key areas affected were along the Danube and Elbe and their larger tributaries. The nature of the event was primarily that of a flood caused by (the slow drainage of) river waters. The area affected by the event (floods with possibility of recurrence/return period of a min. of 5 years) is the largest observed (>46 % of German drainage system considered) for the observational period (since c. 1950). Water levels and discharge in many areas (incl. the Danube, Middle Elbe, Mulde) reached record levels.

As of 09 Jun, this flood event had claimed 8 lives in Germany, and the total number of deaths in all affected countries is 25.<sup>4</sup> A minimum of 52 500 people have been affected by evacuations in the catchment areas of the Elbe and the Danube.

It is still too early for a model-based estimation of the damages by CEDIM. Significant direct and indirect damages are expected in all essential sectors such as residential buildings, business premises, agriculture and infrastructure as well as due to traffic congestion (31 May to 04 June: a min. of 4900 h of flood-related congestion in the German road network), interruptions in business operations and similar consequences. Initial external estimates assume total damages similar to or higher than those incurred during the floods of August 2002 (Fitch Rating: 12 billion euros, German Insurance Association (GdV): same as 2002 at 11.6 billion euros or higher, German flood relief funds amounting to € 8 million).

Based on social, economic and institutional indicators, CEDIM analyzes the resilience (the ability to compensate for external hazards) of selected affected areas in Germany on the district (Landkreise) level. The resilience indicator is supplemented with information on the number of people affected by evacuations per district. Combined with the information on the magnitude of the event (maximum return period of discharge per district), an index is calculated that allows for an initial but **preliminary estimate of the impact of the floods** at the district level for the areas affected.

With the high resilience of the administrative districts along the Danube and the comparatively low number of administrative districts along the Elbe and Mulde, the expected impact of the floods along the Lech and Danube will mainly be at a moderate level (exceptions: the districts Deggendorf, Straubing, Ostallgäu), while heavy impact is expected along the Mulde and Elbe. The calculations for the Middle and Lower Elbe will continue to change markedly, as the event has not yet reached its conclusion.

<sup>3</sup> Wikipedia: [http://de.wikipedia.org/wiki/Hochwasser\\_in\\_Mittleuropa\\_2013](http://de.wikipedia.org/wiki/Hochwasser_in_Mittleuropa_2013) (in German, accessed on 26 Jun 2013)

<sup>4</sup> *ibid.*

## 1 Short overview of floods

Prolonged heavy precipitation together with extremely disadvantageous preconditions led to a large-scale flood event that affected multiple catchments. In terms of extent and overall magnitude, this event exceeded the August 2002 floods and the previous record event: the summer floods in July 1954. The catchment areas of the Danube and the Elbe were particularly affected (see Fig. 1).

In the Danube catchment area, the Danube, Lech, Regen and Inn-Salzach region were especially affected. At the confluence of the Danube and the Inn in Passau, a historical floodwater level of 12.75 m was recorded (03 Jun). In addition to Passau, the district of Deggendorf was particularly affected, where from 5th June onwards the levees were no longer able to hold back the high water levels.

Along the Elbe, the flood wave coming from the Czech Republic had been passing through Dresden, Torgau and Dessau since the 6<sup>th</sup> of June, and reached Magdeburg on the 9<sup>th</sup> of June. Due to the strong inflow from the Saale (in particular Halle) and Mulde, which were also affected, the mouth of the Saale and the downstream areas of the Elbe from that point on (incl. Magdeburg) were especially affected. The water levels along the Middle Elbe, Saale and Mulde reached previous maximum values. In northern Saxony-Anhalt, the breach of a levee at Fischbeck on 10th June resulted in widespread flooding in the Elbe-Havel-Winkel.

Other affected catchment areas are those of the Weser (in particular the Werra) and the Rhine. In these regions, the situation has eased considerably. The flood waves from the Tauber, Main and Neckar did not experience unusual consequences for the flood events in the Central and Lower Rhine areas.

The comparison of the spatial dimensions and the magnitude (Fig. 1) shows the markedly larger spatial extent of the 2013 event and the increased intensity/event magnitude over large areas (Middle and Lower Elbe, Danube, Inn). However, the hydrological classification alone does not allow the forming of any conclusions concerning the amount of expected damage.

**Table 1:** Comparison of significant flood events – Causes, intensity, consequences

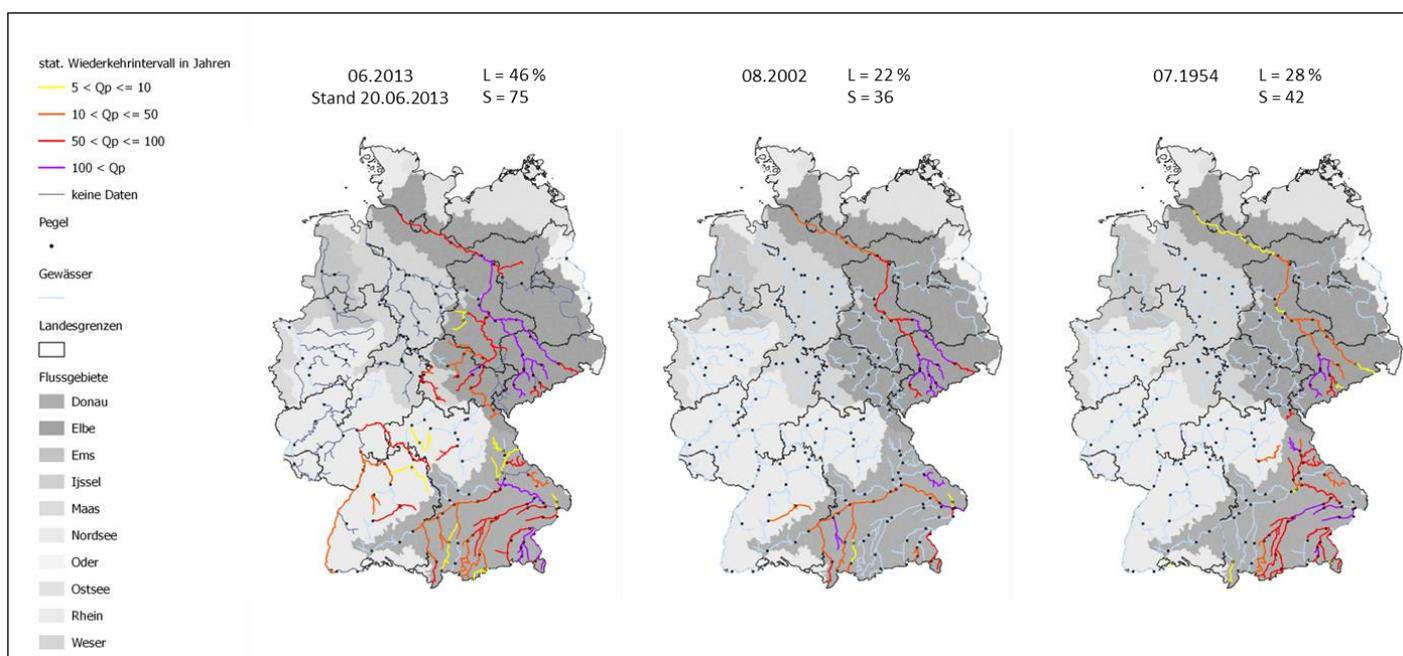
Year – Name	Cause of flood	Waterway(s) and water levels with maximum recurrence interval (in years)	Impact indices <sup>1)</sup> : S: Strength L: spatial extent	Deaths	Economic losses/financial damages
<b>1954 Summer floods</b>	Heavy rains	>200 White Elster, Greiz gauge (TH)	S = 42.4 L = 28.2 %	n.s.	n.s.
<b>1999 Spring floods</b>	Heavy rains	~200 Ammer, Stege gauge, (BY)	S = 24.4 L = 18.7 %	7 (Em-Dat) <sup>2)</sup>	€ 412 mil (Kron 2004) <sup>3)*</sup>
<b>2005 August floods ("the Alpine Floods")</b>	Heavy rains	< 75 Lech, Landsberg/Lech gauge (BY)	S = 19.2 L = 16.9 %	n.s.	€ 190 mil (LfU 2006) <sup>4)</sup>
<b>2002 August floods</b>	Heavy rains	> 500 Freiberger Mulde, Nossen gauge (SN)	S = 35.9 L = 22.4 %	27 (Em-Dat)	€ 11.8 mil (Kron 2004) <sup>3)*</sup>
<b>2013 July floods</b>	<b>High soil saturation followed by heavy rains</b>	<b>~500 Zwickauer Mulde, Wechselburg gauge (SN)</b>	<b>S = 75 L = 46 %</b>	<b>8 (as of 20 Jun 2013)</b>	<b>~12 bil (Fitch Rating – first estimates)</b>

<sup>1)</sup> S: Recurrence interval of peak discharge above HQ5 multiplied by the assigned river length (L: river length with discharge > HQ5 as percentage of entire river network considered, modified according to Uhlemann et al. 2010 (DOI: 10.5194/hess-14-1277-2010))

<sup>2)</sup> EM-DAT (<http://www.emdat.be/database>), queried in June 2012

<sup>3)</sup> Kron 2004: Zunehmende Überschwemmungsschäden: Eine Gefahr für die Versicherungswirtschaft? (Increasing flood damages: A danger for the insurance industry?), ATV-DVWK Bundestagung, Würzburg

<sup>4)</sup> LfU (Bavarian State Environmental Authority) 2006: August-Hochwasser 2005 in Südbayern (2005 August floods in southern Bavaria), Augsburg



**Figure 1:** Comparison of the 1954 and 2002 events with the current June 2013 event: Max. return period in years (probability of flood as a recurrence interval) along the flood affected major rivers

The flood resistance of the affected areas, changes/improvements in flood protection, the differing geomorphology, settlement pattern and hence the exposition of people and material assets have a decisive influence on the extent of the losses and will be analyzed in Chapter 3: Management.

This report concentrates on the impact of the event. Report on the event can be viewed at <http://www.cedim.de/english/2408.php>. In these reports, it is primarily the hydrometeorological nature of the event that will be described in detail.

## 2 Impact and damage

### 2.1 General impact

This flood event has had a great impact on people, transportation and the economy. Numerous levee breaches, e.g. in Bavaria and along the Elbe, resulted in large-scale regional floods. In many areas, often thousands of people were forced to leave their apartments, homes and towns due to evacuation measures. In the Salzland District in Saxony-Anhalt, a volunteer relief worker died during the filling of sandbags and a woman died during an evacuation. In Baden-Württemberg, 3 persons have died since the beginning of the floods, including a fireman. So far, in all affected flood areas in the Czech Republic, Germany, Austria, and Switzerland, a minimum of 25 deaths (8 of which in Germany) have been recorded, and 4 people have been reported missing.<sup>5</sup>

Utilities such as the electrical grid and the local water supply failed during the floods or were shut down as a precautionary measure in order to prevent more extensive damage to the networks. Repairing the utility networks and bringing them back into service may take several more days or weeks in certain cities and districts. Furthermore, there were also a number of disruptions in the area of transportation. In addition to the large-scale flooding of numerous city centers, traffic was also disrupted in the interregional transportation network, and even on federal highways. Due to a breached levee on 10 Jun, the long-distance transportation lines of the Deutsche Bahn AG had to be shut down in the district of Stendal, resulting in trains being canceled and long delays.

In addition, many economic sectors such as agriculture were heavily affected by the floods. "So far, at least 150 000 hectares of grassland and arable land has been flooded, reported the German Farmers' Association (DBV). It is

<sup>5</sup> Wikipedia: [http://de.wikipedia.org/wiki/Hochwasser\\_in\\_Mitteuropa\\_2013](http://de.wikipedia.org/wiki/Hochwasser_in_Mitteuropa_2013) (accessed on 26 Jun 2013)

estimated that the area affected will increase to a total of 250 000 hectares.<sup>6</sup> In large industrial corporations such as Porsche AG (factory in Leipzig), Volkswagen AG (factory in Zwickau) or Südzucker AG (factory in Zeitz), production has stopped temporarily or for longer periods because manufacturing facilities were damaged and/or the company's logistics supply chains were interrupted due to disruptions in transport infrastructure. Medium-sized and small companies in the regions affected by the flood are also heavily affected. The total extent of direct and indirect damages is currently not foreseeable and can only be ascertained once the floodwaters in the affected areas have receded.

Based on currently available information, model-based analyses of direct and indirect damages cannot yet be carried out, as data on the exact extent of the flooding (flood masks from remote sensing data or hydraulic modeling, but most importantly because the corresponding flooding depths are not yet available.

A compilation of initial external damage estimates, primarily from and for (re)insurance purposes is summarized in Table 2 (as of 12 Jun 2012) and shows damages that are on a scale comparable to that of the August 2002 event.

**Table 2:** Information available to date on total damages due to the 2013 June floods (cf.: 2002 August floods: total damages of 11.1 billion euros; adjusted to today's values with BPI: 14.8 billion euros)

Region	Estimate	Date	Source
All affected areas	EUR 16.5 bil	10 Jun 2013	Advisen Insurance Intelligence (as cited in Willis)
All	EUR 10 bil	06 Jun 2013	AIR (at Touchstone presentation in Zurich)
Germany	EUR 12 bil	11 Jun 2013	Fitch Rating
Germany	EUR >11 bil	08 Jun 2013	DIHK (Association of German Chambers of Commerce and Industry)
Germany	EUR 10 bil	06 Jun 2013	AIR (at Touchstone presentation in Zurich)
Saxony	EUR 2.5 bil	06 Jun 2013	Head of Task Force for Reconstruction, Jaeckel (MDR)
Germany	EUR 8 bil	Aid allocated for federal and state flood relief funds	
Austria	EUR 3 bil	10 Jun 2013	Erik Ebyl, Generali (as cited in Willis)
Austria	EUR 2.2 bil	10 Jun 2013	EcoAustria (Economic research institute)

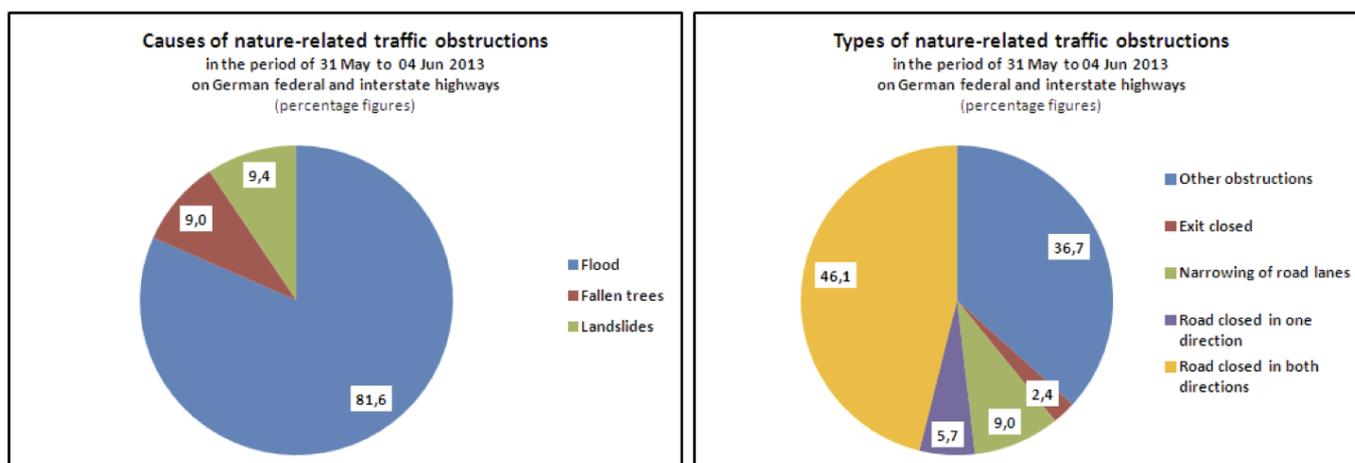
## 2.2 Impact on transport infrastructure

Comprehensive data on the type, extent and duration of the obstruction of traffic is necessary in order to evaluate indirect damages in the transport sector. In order to obtain accurate information on road traffic, ongoing traffic reports from police sources in Germany have been monitored and recorded daily from 6 a.m. to 12 a.m. at 3-hour intervals since Friday, 31 Jun 2013, and filtered for disruptions with a correlation to the flood event. The data compiled is then stored in a database. The construction of this database will continue even after this report has been released.

The first evaluation of the data was carried out for the period from 31 May 2013 at 12 p.m. to 04 Jun 2013 at 12 p.m., initially for the interregional transportation network consisting of federal highways (BAB or Bundesautobahn) and interstate highways. In this evaluation, the causes and types of obstruction of traffic as well as the number and duration of disruptions which can be traced back to the flood event are considered.

Figure 2 shows the percentages of natural causes of traffic disruptions. The main cause at 81.6 % is the risk of floods and the actual flooding of transportation routes, which are subsumed under the category "Floods". In addition, fallen trees and landslides also caused disruptions/blockages in the flow of traffic.

<sup>6</sup> Source: <http://www.tagesschau.de/wirtschaft/hochwasser-schaeden100.html> (in German, accessed on 12 Jun 2013)



**Figure 2 (left):** Causes of nature-related traffic obstructions in the period from 31 May to 04 Jun 2013 on German federal and interstate highways.

**Figure 3 (right):** Types of nature-related traffic obstructions in the period from 31 May to 04 Jun 2013 on German federal and interstate highways.

The term "traffic obstruction" includes disruptions of all types. Figure 3 shows the percentages of the types of obstruction in traffic due to the flood event. 46.1 % of traffic obstructions recorded were roads that had been closed in both directions. The full closure of a road completely interrupts the flow of traffic on the routes affected, and hence probably results in the greatest amount of indirect damages in comparison with other types of obstructions. At 36.7 %, the second most common type of obstruction of traffic is "other obstructions". This includes obstructions such as water or dirt on the road surface or the risk of hydroplaning, the occurrence of which is related to the flood event.

Tables 3 to 5 and Figures 7 and 8 give information on the number and duration of traffic obstructions per district. In total, for the time period considered, traffic disruptions were recorded for federal and interstate highways in 89 German administrative districts. For this purpose, 245 traffic reports related to the flood event from police sources were evaluated. In total, traffic obstructions lasting for a minimum of 4866 hours were recorded. On average, a single disruption lasted for approximately 19.86 hours.

**Table 3:** TOP 10 - Administrative districts according to no. of traffic obstructions

Rank	Administrative districts (Federal state)	No. of traffic obstructions
1	Traunstein (BY)	19
2	Erzgebirgskreis (SN)	10
3	Berchtesgadener Land (BY)	9
	Rheingau-Taunus-Kreis (HE)	9
	Saale-Holzland-Kreis (TH)	9
	Vogtlandkreis (SN)	9
7	Miesbach (BY)	6
	Mittelsachsen (SN)	6
	Reutlingen (BW)	6
	Rosenheim (BY)	6
	Saale-Orla-Kreis (TH)	6

The administrative districts with the highest number of traffic disruptions are ranked in Table 3. In Traunstein, the interstate highways B 304 and B 305 have been particularly affected since the 2nd of June. The B 304 was blocked at multiple locations due to fallen trees and landslides. The B 305 was flooded at several locations. Several sections of the federal highway A 8 in the Traunstein district as well as in the neighboring Rosenheim district were also interrupted due to flooding. In the Erzgebirgskreis district, the interstate highway B 180 was closed due to fallen trees and a landslide, and the B 283 and B 95 were closed due to flooding. In the Vogtlandkreis district, traffic on the interstate highways B 173 and B 169 was interrupted several times due to floods. In the Saale-Holzland-Kreis district, the B 7 and the B 88 were also affected by repeated closures of certain sections. The federal highways A 4 and A 9 in Thuringia were closed mostly for short periods. In the Rheingau-Taunus-Kreis district, multiple sections of the B 42 have been closed due to flooding.

**Table 4:** TOP 10 - Administrative districts according to total duration of traffic obstructions

Rank	Administrative districts (Federal state)	Total duration of traffic obstructions (in h)
1	Erzgebirgskreis (SN)	276
2	Traunstein (BY)	255
	Vogtlandkreis (SN)	255
4	Saale-Holzland-Kreis (TH)	252
5	Rheingau-Taunus-Kreis (HE)	192
6	Greiz (TH)	168
7	Leipzig (SN)	162
8	Miesbach (BY)	153
9	Berchtesgadener Land (BY)	150
10	Mittelsachsen (SN)	147

Figure 5 shows the total duration of traffic obstructions per district. This is extremely high in the Erzgebirge region due to the occurrence of a large number of disruptions that have persisted since 31 May 2013. The total duration of traffic obstructions can also increase with the number of disruptions, which is why most of the TOP 10 districts from Table 3 are also represented in Table 4.

Table 5 and Figure 8 show the average duration of a traffic obstruction in the respective districts. The Wartburgkreis district is at the top of the ranking because the interstate highway B 62 in the district was closed from 31 May 2013 to the end of the time period considered (and beyond). In this district, no other disruptions were reported in the interregional transportation network, resulting in an extremely high average duration. Similarly, the other districts listed in Table 5 also have only a few but long-term disruptions in traffic. It may be assumed that such limited closures on interstate highways can be circumnavigated due to the high density of the transport network in Germany. However, this inference is only possible to a limited extent, as the regional traffic routes were not considered and hence it is not possible to draw a final conclusion on the issue.

In summary, it can be said that the evaluation of the first four days of the flood event already show large-scale obstructions in the traffic sector. The construction of the database mentioned at the beginning will continue in order to enable future assessments for an extended observation period as well as an extended areal analysis that includes regional roads and town areas. Initial results allow the conjecture that the flood event will cause significant impairment of road traffic, resulting in considerable indirect damages.

The expansion of the study to include rail transport as well as inland marine traffic is also planned. Initial reports in the media and press releases such as those from the Deutsche Bahn AG lead to the conclusion that numerous long-term disruptions, interruptions and obstructions are also present in these transport sectors. Considerable indirect damages may also be expected in these areas.

**Table 5:** TOP 10 - Administrative districts according to average duration of a traffic obstruction

Rank	Administrative districts (Federal state)	Average duration of a traffic obstruction (in h)
1	Wartburgkreis (TH)	93
2	Neckar-Odenwald-Kreis (BW)	57
	Ostallgäu (BY)	57
4	Schmalkalden-Meiningen (TH)	51
5	Weimarer Land (TH)	43
6	Schwäbisch Hall (BW)	42
7	City of Jena (TH)	40.5
8	Altenburger Land (TH)	39
9	Bergstraße (HE)	36
10	City of Heidelberg (BW)	34.5
	City of Karlsruhe (BW)	34.5

### 2.3 Analysis of Twitter messages on the impact of the floods

For an extended situational and damage analysis that includes the affected, Tweets (Twitter messages) whose content included references to the ongoing flood event and also contained geographic coordinates (longitude [°] and latitude [°]) were recorded. In order to obtain the best possible coverage of all relevant messages, the real-time Twitter data stream was automatically filtered with a list of event-related keywords. In the second step, the messages identified were examined manually as to their significance.

These records covered the 8 days from 31 May 2013 to 07 Jun 2013 (including 07 Jun). The maps created with this data show the 24-hour situation for each of the days. In the time period mentioned above, a total of 1874 event-related messages from 656 users were recorded. Table 6 shows the ratio of these messages, categorized according to topic. The topics used to categorize the Tweets are as follows:

- General news containing references to the floods (in blue in Figure 7)
- Official weather reports and predictions (in white in Figure 7)
- Messages that report on affected infrastructure (in red in Figure 7)

**Table 6:** Number and sum of messages and the various users according to topic

	No. of messages	No. of users
General	1332	635
Infrastructure	37	27
Official weather reports	505	28
$\Sigma$	<b>1874</b>	<b>656</b>

Furthermore, for reasons of improved clarity due to the small scale of the map (approx. 1:10 000 000), Tweets within a radius of 10 kilometers were also aggregated spatially. The geolocation of individual Tweets takes place via GNSS position data in the form of geographical coordinates that is provided voluntarily by users.

The development over time from Friday to Saturday in Figure 7 already shows a clear clustering of event-related messages in and around the districts that were particularly affected (dark gray). In other areas of Germany, the floods as a topic are only visible in isolated instances. After a short maximum period of Twitter interest in the rest of Germany, it falls markedly towards the end of the week. In the affected districts, it continues to remain an important topic, especially in the area around the southern section of the Elbe (Leipzig, Dresden), and from Thursday onwards in Magdeburg.

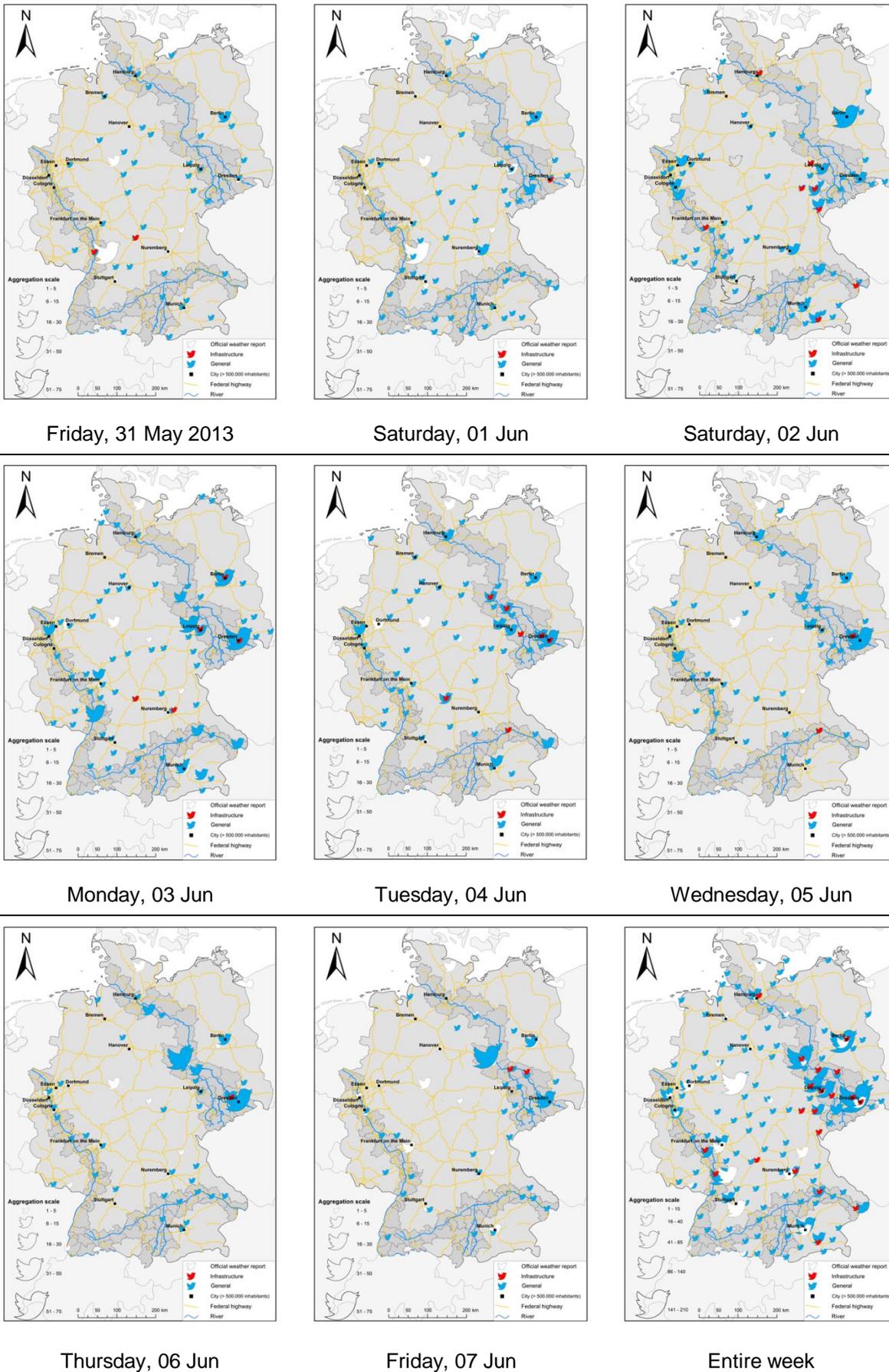


Figure 7: Twitter messages on the impact of the floods per day for the week of 31 May - 06 Jun 2013

In addition to these general trends, concrete information can also be derived from individual messages. Table 7 lists some examples of messages that refer to interruptions in infrastructure.

However, to some extent, the verification of the Twitter messages is difficult. The users mainly report on extremely small-scale events in the inner city area and only seldom on the infrastructure previously considered in the interregional transportation network. Likewise, the flooded roads described are not always officially closed off, and hence are not included in the police reports. The many photos that are included in the Tweets can be viewed as a boost to their credibility. These usually give a clear description of the situation on the ground.

**Table 7:** Examples of Twitter messages (translated from German)

Date	Longitude [°]	Latitude [°]	Message
01 Jun 2013	12.9719	51.7816	B187 completely closed off between #Wittenberg and #Jessen due to #Hochwasser. Detour via #Zahna and #Seyda — plan for delays!
02 Jun 2013	8.0886	50.0202	#Hochwasser along the #Rhein: Water levels rising rapidly. Erbacher underpass blocked. B42 will be closed off starting at Oestrich and maritime traffic will be stopped soon...
02 Jun 2013	12.0689	50.8849	Jolie-Curie-Straße, Schellingstraße and sections of the Leibnizstraße are already under water. #Gera-Untermhaus #Hochwasser #WeißeElster
06 Jun 2013	12.0975	49.0234	Grieser Spitz bridge is closed until further notice. Detour with bicycle across stone bridge possible #Hochwasser #Regensburg #Stadtamhof

## 3 Management

### 3.1 Evacuations

What follows is an overview of the people and animals affected by evacuation measures between 31 May 2013 and 07 Jun 2013. Most of the figures represent minimum values and the information is derived mainly from press releases from the respective administrative districts.

In Saxony, Saxony-Anhalt, Lower Saxony, Bavaria, Brandenburg and Baden-Württemberg, approximately 52 549 people and 650 animals were affected by evacuations due to the flood situation along the Elbe, Danube and Mulde. The evacuations in Saxony affected approximately 26 992 people, 11 669 in Saxony-Anhalt and 9600 in Bavaria.

The first few evacuations were carried out on 01 Jun in the Sigmaringen district in Baden-Württemberg. On 02 Jun, evacuation measures followed in Saxony in the city of Meißen, in the districts of Mittelsachsen, Zwickau, Erzgebirgskreis and Vogtlandkreis. Dresden and the Leipzig district in Saxony, Dessau-Roßlau and the Anhalt-Bitterfeld district in Saxony-Anhalt, as well as Passau and Kelheim in Bavaria would follow on 03 Jun. The state of Saxony-Anhalt intensified its evacuation efforts from 05 Jun onwards. Among the affected were a children's home in the district of Wittenberg housing approximately 70 children, a nursing home in the Salzlandkreis district, 46 severe cases in a hospital in the Jerichower Land district, and in the Anhalt-Bitterfeld district a hospital with 20 intensive care patients and a nursing home. In Magdeburg, a hospital with 420 persons and an old age home were among the facilities evacuated. In a nursing facility for intensive care patients, patients had to be relocated as electricity and district heating had been shut off. Because utilities were shut down for an entire street, bedridden patients had to be transferred out. In the city areas along the eastern section of the Elbe, persons in need of long-term medical care were and continue to be affected by evacuation measures.

In many administrative districts, people saw to it that they obtained private accommodation. In Dresden, a total of 2600 people were affected by evacuations. Two emergency shelters were available. On 06 Jun, an evacuation center was closed. At this point in time, 63 persons were being housed in the other center and 19 persons in nursing homes. Alone in the Meißen district, 1542 persons left their homes and apartments. Approximately 300 persons were housed in temporary accommodation. Of the 8670 affected persons in the district Sächsische Schweiz-Osterzgebirge, 372 persons were located in emergency shelters on 07 Jun. In the district Mittelsachsen, a total of 396 persons were asked to leave their home and living environment by relief workers. On 04 Jun, 73 persons were housed in emergency shelters.

The district of Bitterfeld-Anhalt was the worst affected, with over 10 000 persons affected by the evacuation measures. In the district Sächsische Schweiz-Osterzgebirge, 8670 persons were affected, in the district of Nordsachsen 7000, in the district of Deggendorf 6500, in the district of Leipzig over 6000 and in Brandenburg in the district Elbe-Elster over 4000 persons.

Some of the evacuations were lifted in the course of the week. The evacuation order for Eilenburg in the district of Nordsachsen was lifted on 05 Jun. Likewise the evacuation of Kleutsch and Sollnitz in Dessau-Roßlau. On 07 Jun, the evacuations in the district of Leipzig were lifted, except in Kollau, which is part of the municipality of Thallwitz. The evacuation was also lifted for several smaller towns (Retzau, Schierau, Priorau, Möst) in the district of Anhalt-Bitterfeld. In the district of Straubing-Bogen in Bavaria, the partial lifting of the evacuation of the Gestütt-Insel will take place on 07 Jun 2013.

### **3.2 Resilience in the affected areas: Indicator-based analysis**

According to the ISDR, resilience is defined as Capacity of a system, community or society to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure (ISDR, 2002).. (ISDR, 2002). Resilience is a complex and dynamic concept that encompasses many dimensions. In order to quickly assess resilience potential, an analysis was carried out at the district level based on the sociodemographic and socioeconomic profile and the institutional capacities of the administrative districts. From this, an overall index was developed for the three main dimensions of resilience in Germany — social, economic and institutional resilience (Figure 10) and applied to the data of the German Federal Statistical Office (Destatis, 2013). The selection of the indicators for this was based on the following studies: 1) With the aid of data from a household survey, Fekete (2009) developed an overall index for social vulnerability to river floods after the 2002 floods; 2) Cutter et al (2010) developed a set of indicators for resilience to catastrophes based on the rebuilding process in the aftermath of Hurricane Katrina; and 3) Hiete et al (2012) translated the indicators developed by Cutter et al (2010) to the situation in Germany and applied them to the level of the administrative district.

In his study, Fekete (2009) examined 41 socio-economic variables. On the one hand, this was to filter out components of social vulnerability, while on the other, this was also to describe social vulnerability viewed against river floods in Germany with the smallest possible number of variables. The result was validated with an independent data set from household surveys on disaster management, evacuation and protective measures during and/or after the 2002 floods in Germany.<sup>7</sup> Of the 1697 survey participants, 765 had to leave their apartment or house during the floods, and 70 had to be housed in emergency shelters. These two test categories (evacuation, evacuation + emergency shelter) were used in the study to develop social group profiles (Fekete 2009). The findings show that the probability of having to leave one's apartment or home is accompanied by the following indicators: For persons in old age (above 65 years of age) and tenants (as opposed to homeowners), there was an increased probability of being housed in emergency shelters. Inhabitants of an urban region and the number of rooms in the apartment/house were used as a proxy for financial resources in the study, and reduced this probability. Persons with a low educational level and those who are unemployed also displayed a greater degree of dissatisfaction with damage claims settlement. It was assumed in the study that the dissatisfaction with the settlement stood as an indicator for difficulties during economic crisis management, with bureaucratic requirements for the settlement, and for the perception of the event (Fekete, 2009).

The results of the logistic regression in the validation study by Fekete (2009) were used to assign the variables weightings as descriptors of social vulnerability to floods. While vulnerability primarily refers to factors that lead to lower resistive, regenerative and reconstructive abilities, resilience refers to the situation during and after catastrophes. The translation of the indicators developed by Cutter et al. (2010), which were originally developed for the USA, onto resilience dimensions of German administrative districts took place based on the study by Hiete et al. (2010).

The three studies provided the basis for defining relevant indicators for social, economic and institutional resilience and for applying them to publicly available data (see Table 8). The weighted sum of these indicators constitutes an index for resilience that was devised for the districts affected by the 2013 floods: Rhine, Danube, Lech, Elbe and

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<sup>7</sup> The data set was provided by the GFZ Potsdam (German Research Center for Geosciences) and the Deutsche Rück (German Reinsurance).

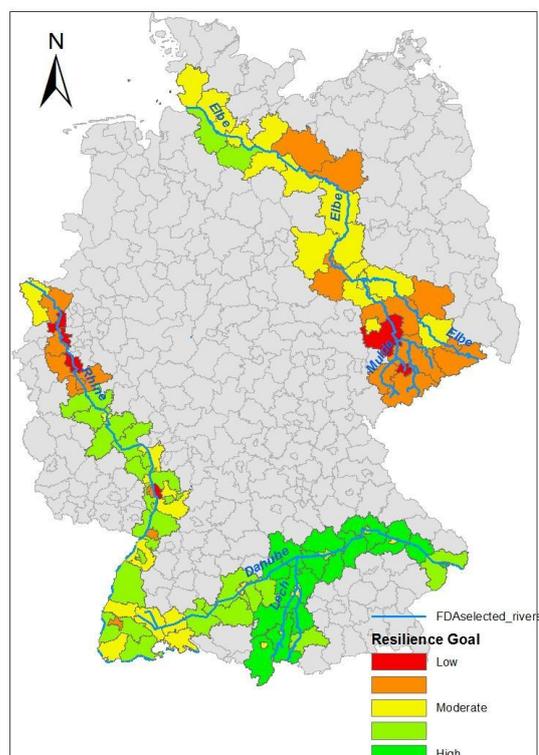
Mulde (Table 9 and Figure 10). Based on the indicators listed in Table 8, this results in an initial overview of the/a resilience pattern in the areas potentially affected by the 2013 floods. It then becomes clear that the resilience is highest in southern Germany and lowest in eastern Germany and in metropolitan areas.

**Table 8:** Resilience indicators

Dimension	Factor	Indicator	Influence on resilience
Social resilience	Education	Percentage of population without a school leaving certificate (Hauptschulabschluss)	-
	Age	Percentage of elderly (> 65 years) Percentage of children (< 6 years)	-
	Special requirements	Percentage of population in need of long-term care	-
Economic resilience	Employment	Percentage of unemployed	-
	Number of rooms	Living space per person (cubic meter per person)	+
	Home ownership	Percentage of single family and duplex houses	+
	Income disparity	Percentage of population receiving social welfare	-
Institutional resilience	Law and order	Public spending for internal security per person	+
	Crisis management and social involvement	Percent of population active in voluntary fire service	+
	Medical capacity	Number of hospital beds per 10 000 inhabitants	+

**Table 9:** TOP 10 and BOTTOM 10 administrative districts according to highest and lowest overall index for resilience

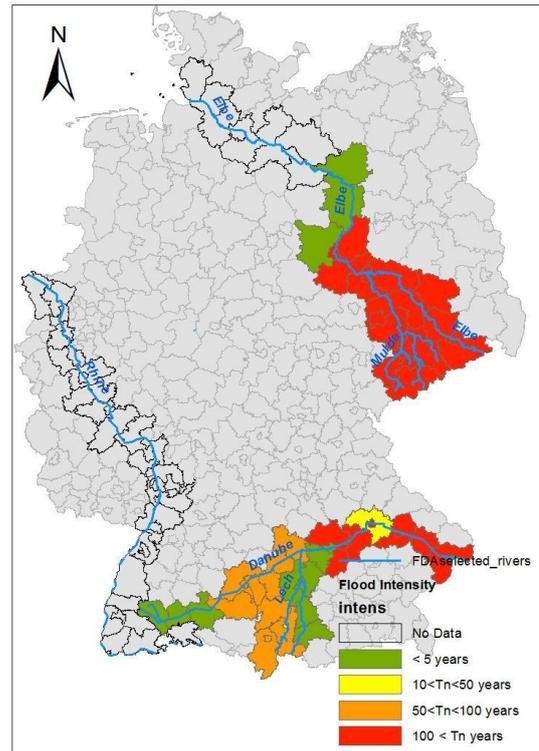
Top 10 Rank	District	Resilience index
1	Eichstätt	0.667
2	Straubing-Bogen	0.661
3	Regensburg	0.658
44	Deggendorf	0.646
5	Unterallgäu	0.644
6	Neuburg-Schrobenhausen	0.641
7	Donau-Ries	0.640
8	Ostallgäu	0.638
9	Aichach-Friedberg	0.637
10	Kelheim	0.635
Bottom 10 Rank	District	Resilience index
1	Duisburg	0.349
2	Düsseldorf	0.386
3	Leipzig	0.391
4	Cologne	0.399
5	Chemnitz	0.411
6	Zwickau	0.415
7	Krefeld	0.416
8	Ludwigslust	0.420
9	Magdeburg	0.421
10	Dresden	0.425



**Figure 8:** Overall index for resilience of the administrative districts along the rivers transporting floodwaters.

**Table 10:** Districts according to max. repeat period in years along the rivers transporting floodwaters

District	Intensity: $T_n = \text{repeat period (years)}$
Kelheim	$T_n > 100 \text{ y.}$
Eichstätt	
Pfaffenhofen a. d. Ilm	
Regensburg	
Deggendorf	
Straubing	
Passau	
Sächsische Schweiz - Osterzgebirge	
Dresden	
Meißen	
Nordsachsen	
Elbe-Elster	
Wittenberg	
Salzlandkreis	
Leipzig	
Dessau-Roßlau	
Anhalt-Bitterfeld	
Magdeburg	
Jerichower Land	
Mittelsachsen	
Erzgebirgskreis	
Zwickau	
Chemnitz	
Leipzig	
Kempten (Allgäu)	$50 < T_n < 100 \text{ y.}$
Oberallgäu	
Unterallgäu	
Dillingen a. d. Donau	
Neu-Ulm	
Biberach	
Günzburg	
Ulm	
Alb-Donau-Kreis	
Donau-Ries	
Ostallgäu	
Kaufbeuren	$10 < T_n < 50 \text{ y.}$
Regensburg	



**Figure 9:** Districts according to max. repeat period in years along the rivers transporting floodwaters in the period from 31 May to 07 Jun 2013

### 3.3 Analysis of the impact of the floods

For an initial, preliminary analysis on the impact of the floods, the administrative districts along the selected river systems were compared and ordered according to the following types of impact:

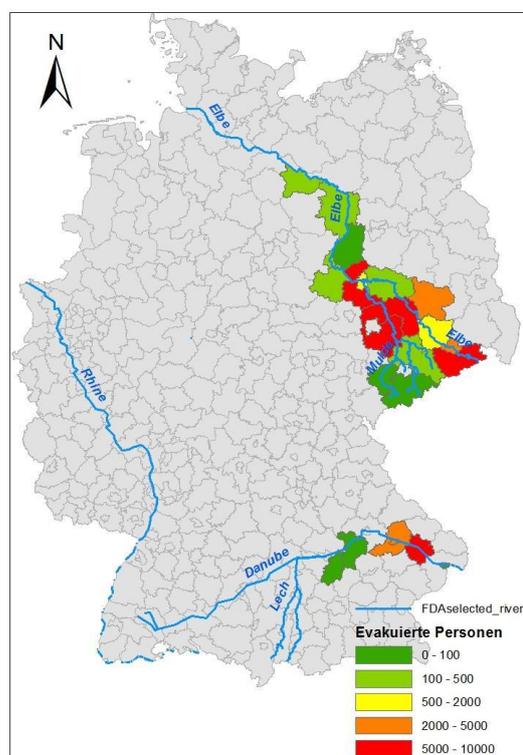
- Max. repeat period in years along the rivers transporting floodwaters in the period from 31 May to 07 Jun 2013 (Table 10 and Figure 9)
- Number of persons affected by evacuations along the rivers transporting floodwaters in the period from 31 May to 07 Jun 2013 (Table 11 and Figure 10)
- Traffic obstructions in the period from 31 May to 04 Jun 2013 on German federal and interstate highways (Table 12 and Figure 11)

Subsequently, the information on the impact was combined with the indicators for resilience via the intersection of various planes. To do so, the values for the intensity of the floods (according to repeat period), the number of people affected by the floods and the extent of traffic disruptions was added to the potential for resilience, which was determined via the resilience index (see section 3.2). In this manner, a map with a preliminary estimate of possible flood consequences was created, whereby the flood intensity was weighted at 40 %, the number of people affected by evacuations at 30 %, traffic disruptions at 20 % and weak resilience or the lack of resilience was weighted at 10 % (Table 11 and Figure 12).

Economic damages and levee breaches could not yet be considered at the time of this preliminary analysis. In addition, the flood situation had already developed past the data included in the analysis and will continue to do so. The analysis is based on information compiled for the time period 31 May to 07 Jun 2013 (flood intensity, no. of people affected by floods) and/or for the period 31 May 2013 to 04 Jun 2013 (traffic disruptions).

**Table 11:** Administrative districts according to number of people affected by evacuations along the rivers transporting floodwaters

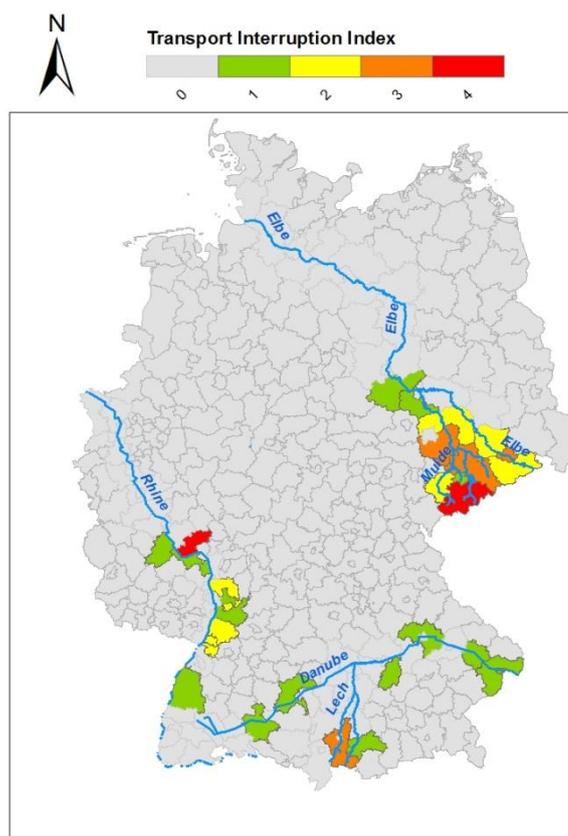
Rank	District	Persons
1	Anhalt-Bitterfeld	> 10 000
2	Sächsische Schweiz - Osterzgebirge	8670
3	Nordsachsen	> 7000
4	Deggendorf	> 6500
5	Leipzig	> 6000
6	Elbe-Elster	> 4000
7	Straubing-Bogen	approx. 3000
8	Dresden	2600
9	Meißen	1542
10	Vogtlandkreis	approx. 750
11	Dessau-Roßlau	approx. 640
12	Salzlandkreis	approx. 453
13	Magdeburg	> 420
14	Mittelsachsen	396
15	Lüchow-Dannenberg	approx. 280
16	Wittenberg	approx. 110
17	Passau	60
18	Jerichower Land	46
19	Pfaffenhofen a.d. Ilm	> 32
20	Erzgebirgskreis	23
21	Zwickau	> 11
22	Kelheim	9
23	Sigmaringen	> 7



**Figure 10:** Districts: Number of persons affected by evacuations along the rivers transporting floodwaters in the period from 31 May to 07 Jun 2013

**Table 12:** Overall index for traffic obstructions per administrative district in the period from 31 May to 04 Jun 2013 on German federal and interstate highways.

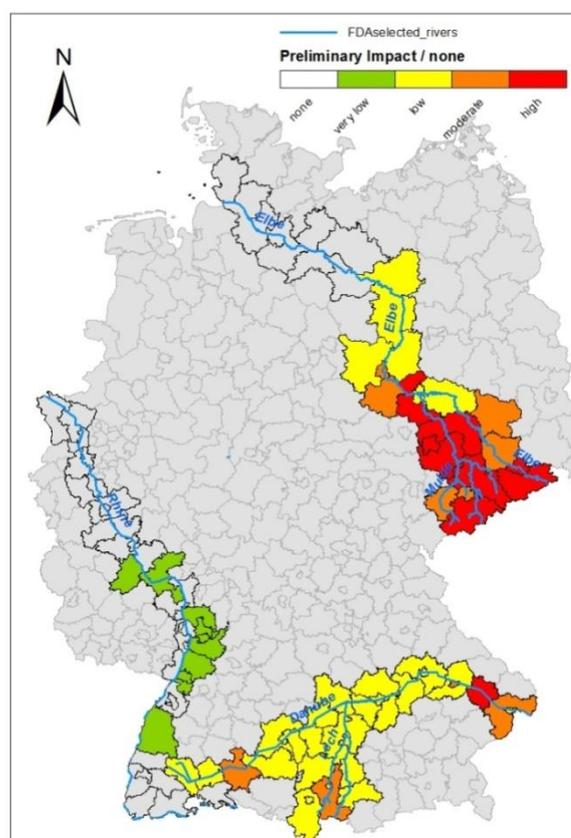
Rank	District	Traffic obstructions — Overall index
1	Erzgebirgskreis	1.0000
2	Rheingau-Taunus-Kreis	0.9000
3	Dresden	0.7000
4	Leipzig	0.7000
5	Mittelsachsen	0.7000
6	Ostallgäu	0.6000
7	Nordsachsen	0.5000
8	Karlsruhe	0.5000
9	Heidelberg	0.5000
10	Sächsische Schweiz - Osterzgebirge	0.4000
11	Meißen	0.4000
12	Zwickau	0.4000
13	Bergstraße	0.4000
14	Anhalt-Bitterfeld	0.3000
15	Deggendorf	0.3000
16	Salzlandkreis	0.3000
17	Chemnitz	0.3000
18	Passau	0.3000
19	Alb-Donau-Kreis	0.3000
20	Sigmaringen	0.3000



**Figure 11:** Overall index for traffic obstructions per administrative district in the period from 31 May to 04 Jun 2013 on German federal and interstate highways.

**Table 13:** Preliminary impact of the flood according to max. repeat period in years along the rivers transporting floodwaters; number of persons involved in the evacuation measures; traffic obstructions on German federal and interstate highways and overall index for resilience per administrative district for the time period 31 May to 07 Jun 2013.

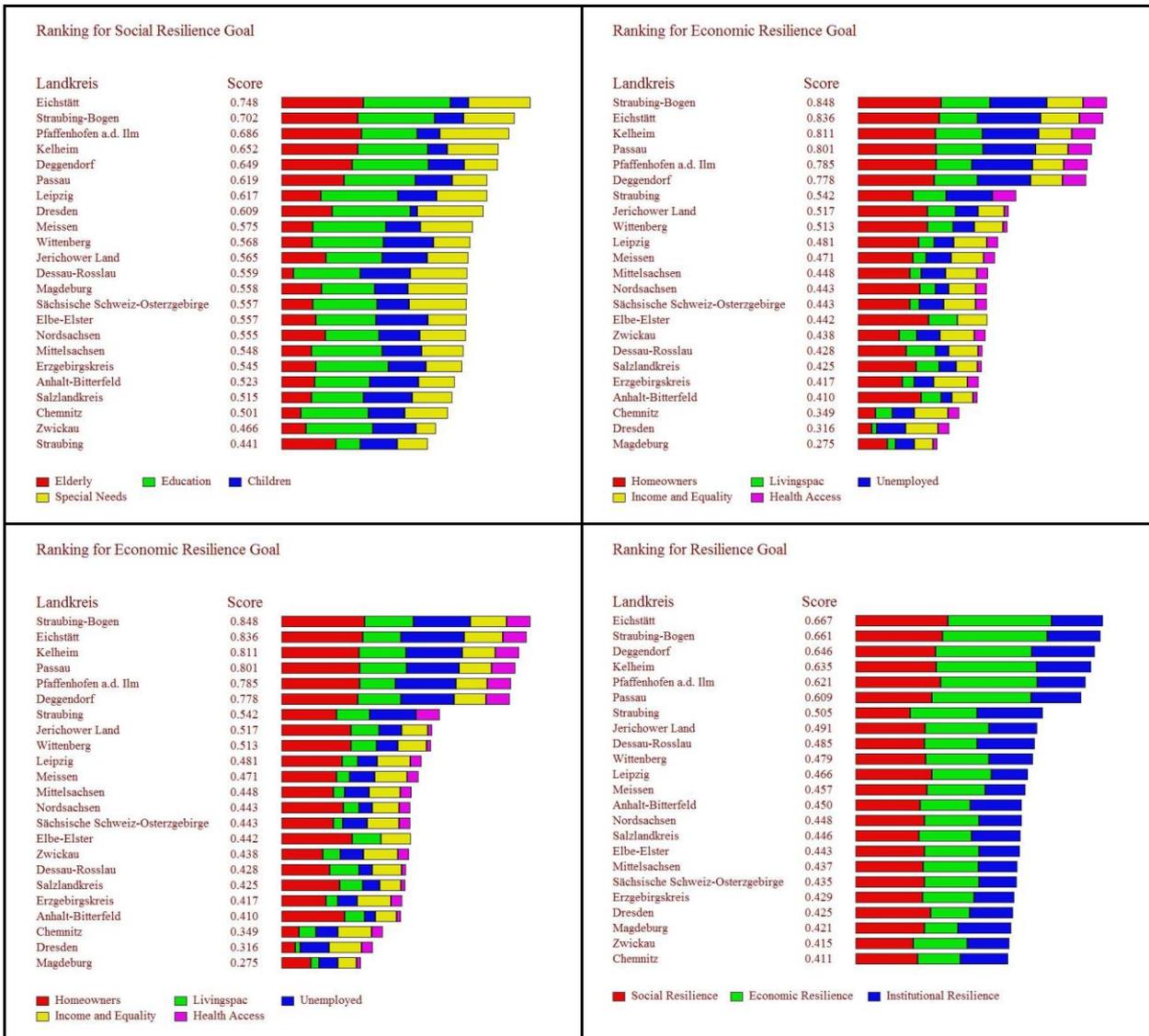
Rank	District	Flood impact index
1	Anhalt-Bitterfeld	0.8913
2	Sächsische Schweiz - Osterzgebirge	0.8451
3	Nordsachsen	0.7894
4	Dresden	0.7327
5	Erzgebirgskreis	0.7242
6	Leipzig	0.6878
7	Deggendorf	0.6276
8	Mittelsachsen	0.6253
9	Meißen	0.6008
10	Elbe-Elster	0.5982



**Figure 12:** Preliminary flood impact per administrative district for the time period 31 May to 07 Jun 2013

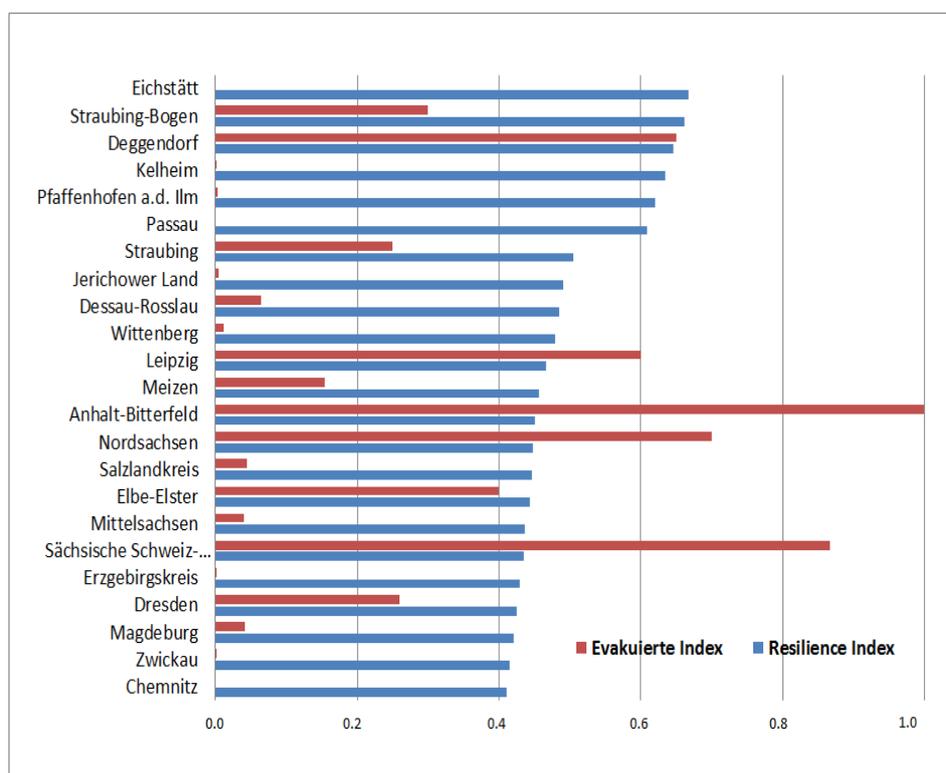
### 3.4 Comparison of resilience potential and evacuations

From 31 May to 07 Jun 2013, 23 administrative districts were affected by floods with a repeat period of 100 years or more. As the districts experienced comparable flood intensity, a relative comparison of the districts can be made for the resilience index along the three dimensions — social, economic and institutional (see Figure 13).



**Figure 13:** Ranking of the administrative districts with repeat periods greater than  $T_n = 100$  years according to indicators for social (top left), economic (top right), institutional (bottom left), resilience and overall resilience index (bottom right).

As soon as better information on the surface area affected by the floods is available, the elements listed may also be considered and drawn on for normalization. In addition, the evacuation measures are also contingent on levee breaches, which cannot yet be appropriately considered in the analyses at the present time. However, the resilience index and the number of people affected by evacuations can be contrasted as a preliminary overview. (see Figure 14). Even though the pattern is not entirely distinct, the districts with a higher resilience index seem to have required the institution of less evacuation measures. As soon as more information on flooded areas and damages becomes available, the spatial distribution of the resilience can be validated in accordance with the indicators. The consideration of evacuation models (e.g. number of persons affected by evacuations, number of persons housed in emergency shelters), degree of preparedness and effectiveness of crisis management during the 2013 floods can help with the evaluation and understanding of the factors and trends of (flood) resilience in Germany through further research, and ultimately help improve resilience.



**Figure 14:** Comparison of persons in evacuation measures and resilience index for administrative districts with repeat periods of  $T_n > 100$  years along the rivers transporting floodwaters.

## 4 Literature and sources

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Hiete, M., et al. (2012): "Trapezoidal fuzzy DEMATEL method to analyze and correct for relations between variables in a composite indicator for disaster resilience." *OR spectrum* 34.4 (2012): 971 - 995

ISDR (2002): *Living with Risk: A global review of disaster reduction initiatives*. Preliminary version, UN, Geneva.

The information provided on evacuations in chapter 5 are based on the following sources (mainly in German):

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[www.stadt-meissen.de](http://www.stadt-meissen.de)

<http://www.landkreis-nordsachsen.de/r-aktuell-a-3133.html>

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http://www.spiegel.de

*This report as well as other reports and information on the 2013 June floods and updates can be accessed online at [www.cedim.de](http://www.cedim.de).*

*For a better understanding of technical terms, CEDIM has made available the glossary "Terms and definitions of risk sciences" online at [www.cedim.de/download/glossar-gesamt-20050624.pdf](http://www.cedim.de/download/glossar-gesamt-20050624.pdf).*