Risk label method for a flood proof electricity network

The goal of the risk label method is to gain insight in the vulnerability of the electricity network in a certain area, due to flooding in case of a dike breach or due to extreme rainfall. The analysis process is depicted in Figure 1 below. In the remainder of this text, the different steps of this process will be shortly explained. This analysis was applied to a study in the province of Zeeland, to investigate the vulnerability of the local electricity network. Some results from this risk label analysis in Zeeland will be described as well.

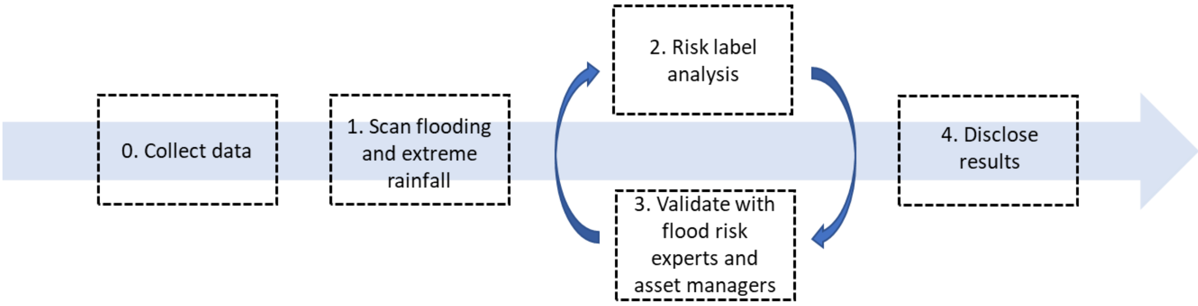

Figure 1: flowchart of the risk label method

Step 0 and 1: Collect data & scan flooding and extreme rainfall

In order to perform the risk label analysis, the following data needs to be collected:

- **Maximum water depths due to flooding in case of a dike breach.** For the analysis of Zeeland, the Dutch national flooding scenario's (Landelijke Database Overstromingsscenario's) were used. These maps show the maximum water depths that are expected to occur for different dike breaches for return periods of 400, 4000, 40.000 and 400.000 years.

- **Maximum water depths due to extreme rainfall.** The maximum water depth due to extreme rainfall were obtained from maps in the Klimaatatlas. For the case of Zeeland, the water depths due to extreme rainfall are in the order of a few centimeters and will therefore not influence the electricity network.

- **Critical water depths for all electricity assets.** Apart from the maps with maximum water depths for different return periods, the water level at which an electricity asset is going to fail needs to be determined. Therefore, the height from the ground up to the crucial installation needs to determined. Once the water level reaches up to this installation, the asset will fail. This height is therefore called the critical depth. For the Zeeland case, this critical depth was measured by the local electricity company Enduris, for all assets in the network. A default height determined by experts is also a possibility for a first impression.

2. Risk label analysis

Based on the location and critical height of the electricity assets, and the maximum water depths linked to different return periods, insight can be obtained in the vulnerability of the electricity assets. The vulnerability is expressed in terms of a risk label, ranging from label A till G. This risk label is comparable to the energy labels that are used for households; the higher the label, the better. Label A means that the electricity asset has a low vulnerability, while label G means a high vulnerability.

In the Zeeland case, the risk labels were based on 4 different characteristics. However, more characteristics can be used if desired. This will depend on the area and can be discussed with the asset managers and flood risk experts (see step 3). Each electricity asset is assigned a score for each of the characteristics. These scores are then summed up and linked to a final risk label. In the Zeeland case, the following characteristics were used:

1. <u>The chance of flooding up to the critical depth.</u> For each flooding scenario, the maximum water depth was compared to the critical depth for all assets, to determine the chance of flooding. For the Zeeland case, 500 flooding scenarios were analyzed to determine the chance of flooding for each electricity asset. In this analysis, the chance of flooding was equal to the exceedance probability of the flooding scenario with the lowest return period, that still led to flooding of the asset up to the critical depth.
2. <u>Number of affected connections</u>. Based on an advanced network analysis, the amount of connections that will fail when a certain asset fails are determined. For the Zeeland case, the number of connections ranged from 0 up to more than 500 per asset.
3. <u>Vulnerable objects.</u> In the determination of the risk label, vulnerable objects are also taken into account. If for example the electricity in a hospital fails, this poses a larger risk compared to a few households. In the case of Zeeland, only vulnerable objects with overnight accommodation (e.g. hospitals or retirement homes) are taken into account. However, more vulnerable objects can be taken into account if desired.
4. <u>Direct or indirect failure.</u> In Figure 2, the difference between direct and indirect failure is explained. When an asset fails because it is flooded, this is called direct failure. However, when an asset fails because of a flooding in another area, this is called indirect failure. Indirect failure will result in a lower score, because it is easier to repair the asset if the asset itself is not flooded.

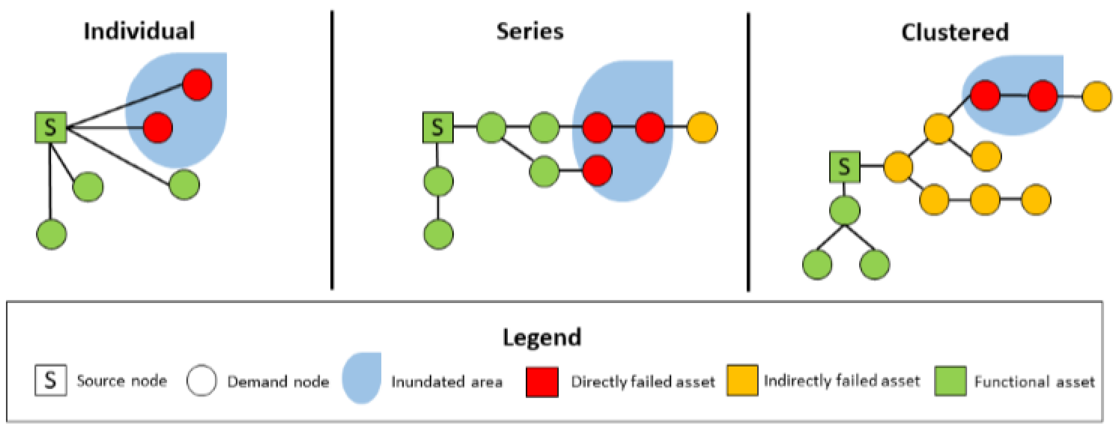

Figure 2: Schematization of the difference between direct and indirect failure of electricity assets

For each characteristic, different classes and scores can be developed. Eventually, the score for the different characteristics can be summed up for each asset and linked to the final risk label. In table 1 till 3 below, the classes and scores that were applied in the Zeeland case are depicted. However, when applying this method in another area, these classes and scores might have to be adjusted to the specific case. Depending on the goal of the analysis, it can be recommended to choose the classes and scores in such a way, that some variety in risk labels is achieved within the area of interest. In that way, insights can be obtained in the relative vulnerability of the electricity assets in a certain area, that might serve as input for the prioritization of further research or measures.

Chance of flooding	Score
Maximum water level < critical depth	0
1: 400000	4
1: 40000	8
1: 4000	12
1: 400	15

Table 1: Score table for chance of flooding

Number of connections	Score	Vulnerable objects	Score	Direct/Indirect	Score
None	0	No	0	Indirect	1
0 – 50	1	Yes	5	Direct	5
51 – 100	2				
101 – 250	3				
251 – 500	4				
>500	5				

Table 2: Score table for the consequences of flooding

Score	Label
0 – 10	A
10 – 13	B
13 – 16	C
16 – 19	D
19 - 22	E
22 – 25	F
>25	G

Table 3: Score table for the risk label

3. Validate with asset managers and flood risk experts

It is important to validate the outcomes of the flooding- and electricity network analyses together with asset managers that have a lot of practical knowledge regarding the electricity network and experts that know how to interpret the flood scenarios. As described above, the characteristics, classes and scores that will be used may depend on the area in which the risk label method is applied. Therefore, the exact method that is applied for determining the risk labels can be adjusted in cooperation with these asset managers. In practice, this will result in a feedback loop between step 2 and 3 (see Figure 1).

4. Disclose results

The results of the risk label method can be visualized in a map, as is depicted in Figure 3 below. In this way, more insight in the spatial variation of the vulnerability of the electricity network can be obtained. The final report of the Zeeland case with all results can be found here: https://www.zeeland.nl/sites/zl-zeeland/files/eindrapport_frames_elektriciteitsnetwerk_geredigeerd.pdf.

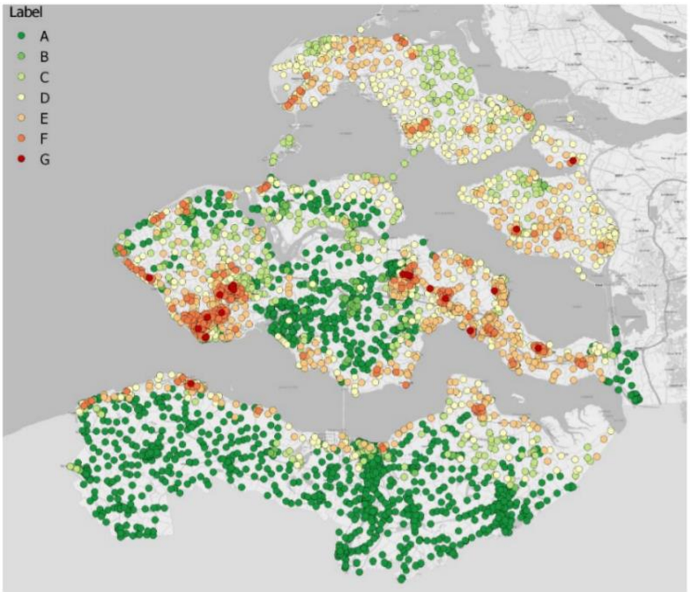

Figure 3: Risk label for all electricity assets in Zeeland

More information

The risk label method for a flood proof electricity network supported the development of risk maps for the Dutch Climate Atlas. The Climate Atlas is widely used by communities, provinces and water boards. See for example the maps about the vulnerability for pluvial flooding of the electricity, IT and telecom networks: https://parkstad.klimaatatlas.net/.