Application of climate risk assessment framework for some Italian airports

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QUARTO CONGRESSO NAZIONALE AISAM 15-19 FEBBRAIO 2022

1. Objective of research

The impacts of climate change on the aviation sector are well known, but in Europe and especially in the Mediterranean basin, there is no clear methodology to assess climate risks for the airports (Gratton et al. 2020). The objective of the research is to propose a clear and detailed methodology to define the level of climate risk on airport infrastructures in the **Mediterranean region**. We apply these frameworks to some of the main **Italian airports** (Milano Malpensa, Milano Linate; Bergamo Orio al Serio; Roma Fiumicino; Roma Ciampino; Napoli Capodichino; Catania Fontanarossa; Palermo Punta Raisi; Cagliari Elmas) to quantify the present and expected level of risk associated to each hazard, with the goal to support the identification of specific adaptation measures.

2. Methodology

According to framework proposed by IPCC 2014, the climate risk is a result of the interaction of **hazard** (**H**), **exposure** (**E**) and **vulnerability** (**V**) (Oppenheimer et al. 2014; Carrão et al. 2016; GIZ 2017; Ellena et al. 2020; Shah et al. 2020) (*Figure 1*). The term "**hazard**" usually refers to "the potential occurrence of a natural or human-induced physical events or trend or physical impacts that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources" (IPCC 2014, GIZ 2017). The term "**exposure**" refers to "the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected" (IPCC 2014, GIZ 2017). "**Vulnerability**"(divided into Sensitivity and Adaptive Capacity) reflects "the propensity or predisposition of a system to be adversely affected (GIZ 2017).

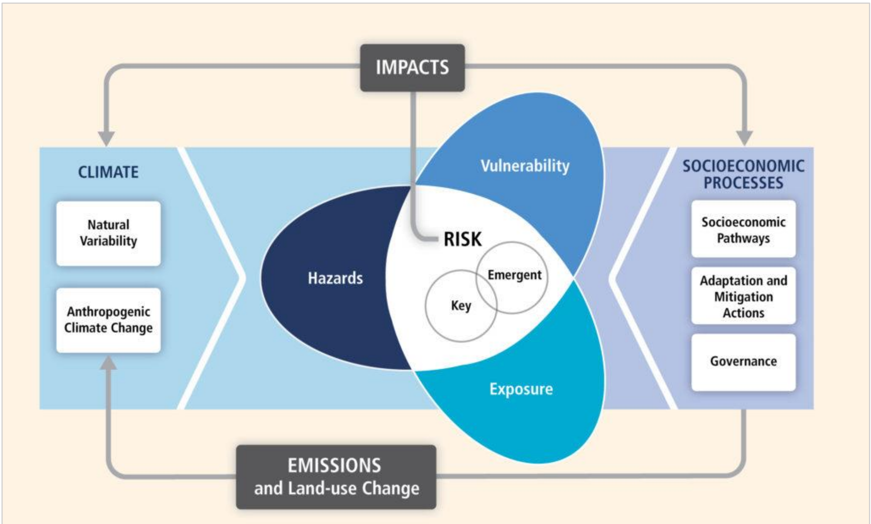

Figure 1: Illustration of the risk concept of the Fifth Assessment Report of IPCC 2014 .

Based on the state-of-the-art literature, the theoretical frameworks for risk assessing for the mediterranean airport were constructed through the identification of specific indicators of hazard, exposure and vulnerability. In this context, hazard refers to the potential occurrence of climatic events that could damage the airport and compromise its operations. The Mediterranean region - defined as a climate hot spot by Giorgi (2006) - will be affected by the intensification of extreme temperature and extreme precipitation phenomena and sea level rise (**hazard**). For each hazard, we selected specific indicators that describe the variability of the climatic extremes in terms of frequency and intensity. We considered both absolute and percentile-based threshold indices. These thresholds describe the climatic conditions under which physical damages to infrastructures might occur and airport operations could be impaired. We considered the various airports components as **exposed samples**. From an operational point of view, the airport is generally divided into two main areas of activity: the landside and airside activities (Alba and Manana 2016). Finally, we selected specific **sensitivity** and **adaptive capacity** indicators based on the exposure sample under analysis (*Figure 2,3,4*).

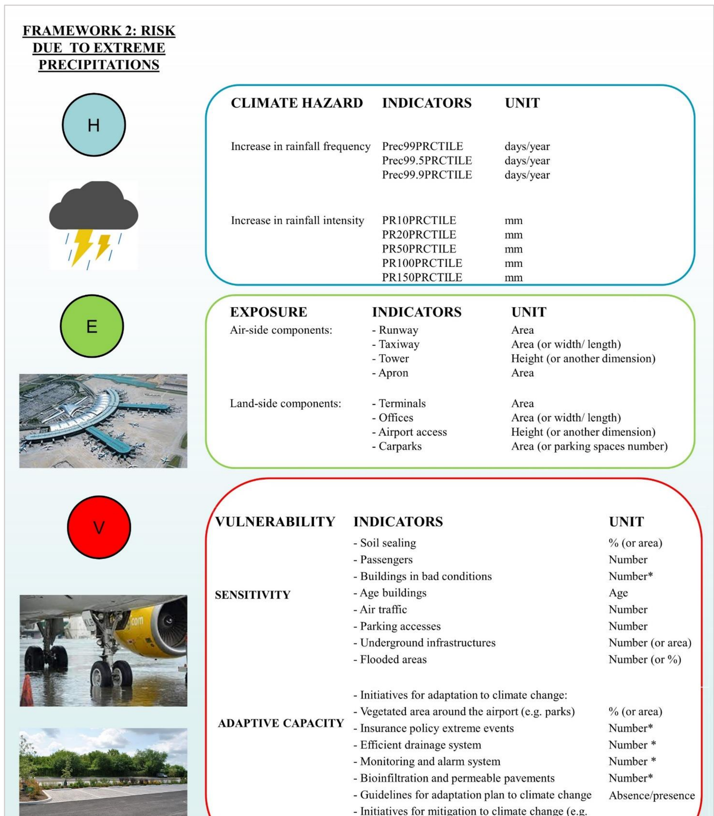

Figure 2: Framework relating to the risk due to extreme temperatures (De Vivo et al., 2021)

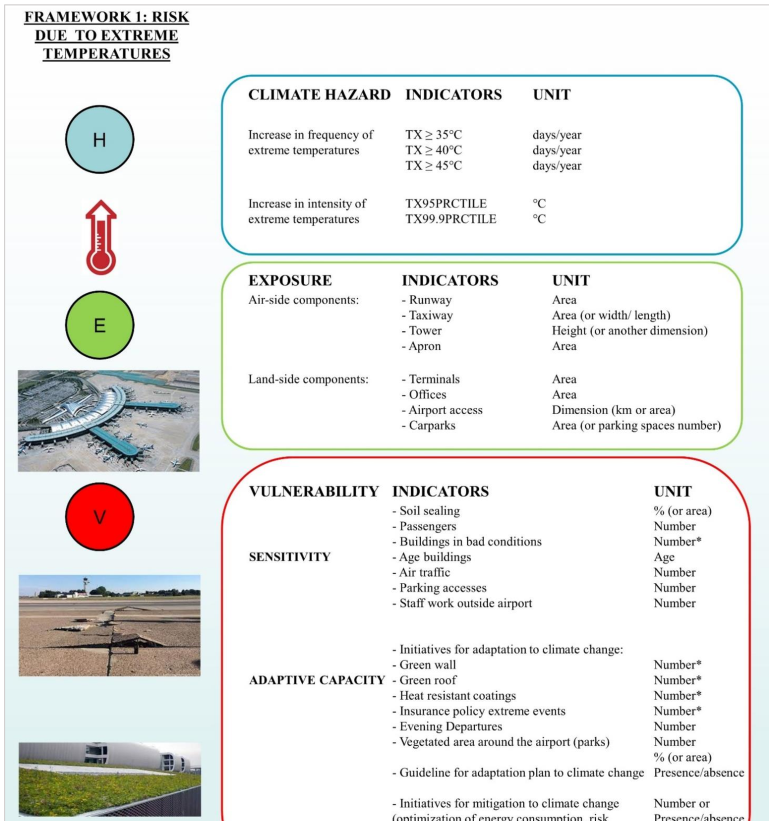

Figure 3: Framework relating to the risk due to extreme precipitation (De Vivo et al., 2021)

After collected the hazard, exposure and vulnerability data, the next step is to normalize the indicators with the **min-max method.** This method normalizes the measures to have an identical range (from 0 to 1) by subtracting the minimum value and dividing it by the range of the measured values.

After normalizing the data, it is necessary to calculate the synthetic Hazard, Exposure and Vulnerability Index by aggregating the results of the individual indicators, using the "**weighted arithmetic aggregation**". Vulnerability Index formula implies a simple average between sensitivity and adaptive capacity indicators.

The last step involves estimating risk index with weighted arithmetic mean to combine the three components In order to obtain comparable risk classes, the **"quantile classification method"** (implemented in ArcGIS) was used in which each class contains an equal number of characteristics. The number of classes adopted for the representation of the risk level is five: **very low**, **low**, **intermediate**, **high**, **very high**.

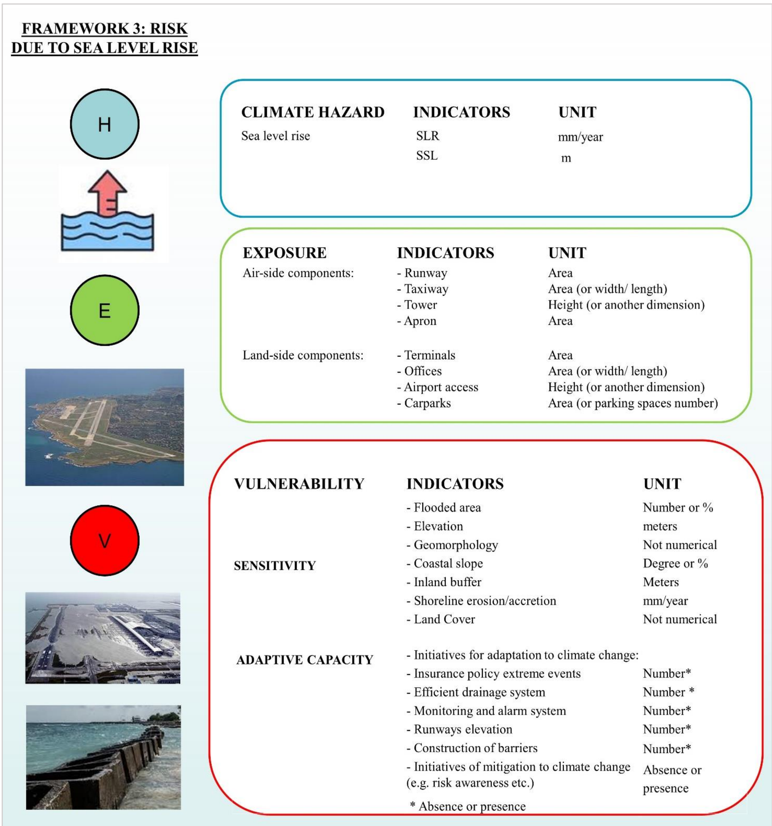

Figure 4: Framework relating to the risk due to sea level rise (De Vivo et al., 2021)

3. Application of the proposed methodology for some Italian airports: a focus on extreme temperatures and precipitation

Study areas and data used to calculate the risk components

HAZARD

Dataset **UERRA MESCAN-SURFEX** (resolution 5 km) was used to calculate the extreme temperature and extreme precipitation indicators in the observed period (1988-2017) for the airports under analysis .

Ensemble of the **Regional Climate Models** from the **EURO-CORDEX** initiative - present and future dynamical downscaling simulations - at the highest resolution over Europe (about 12 km) were used to assess the variation of the selected indicators in the near future (2021-2050) for the RCP 2.6, RCP 4.5 and RCP 8.5 IPCC scenarios.

EXPOSURE AND VULNERABILITY

The exposure index was obtained using the information contained in the «Atlante degli Aeroporti Italiani, 2010» while the information about vulnerability is taken from the websites and official documents available for each single airport.

Results

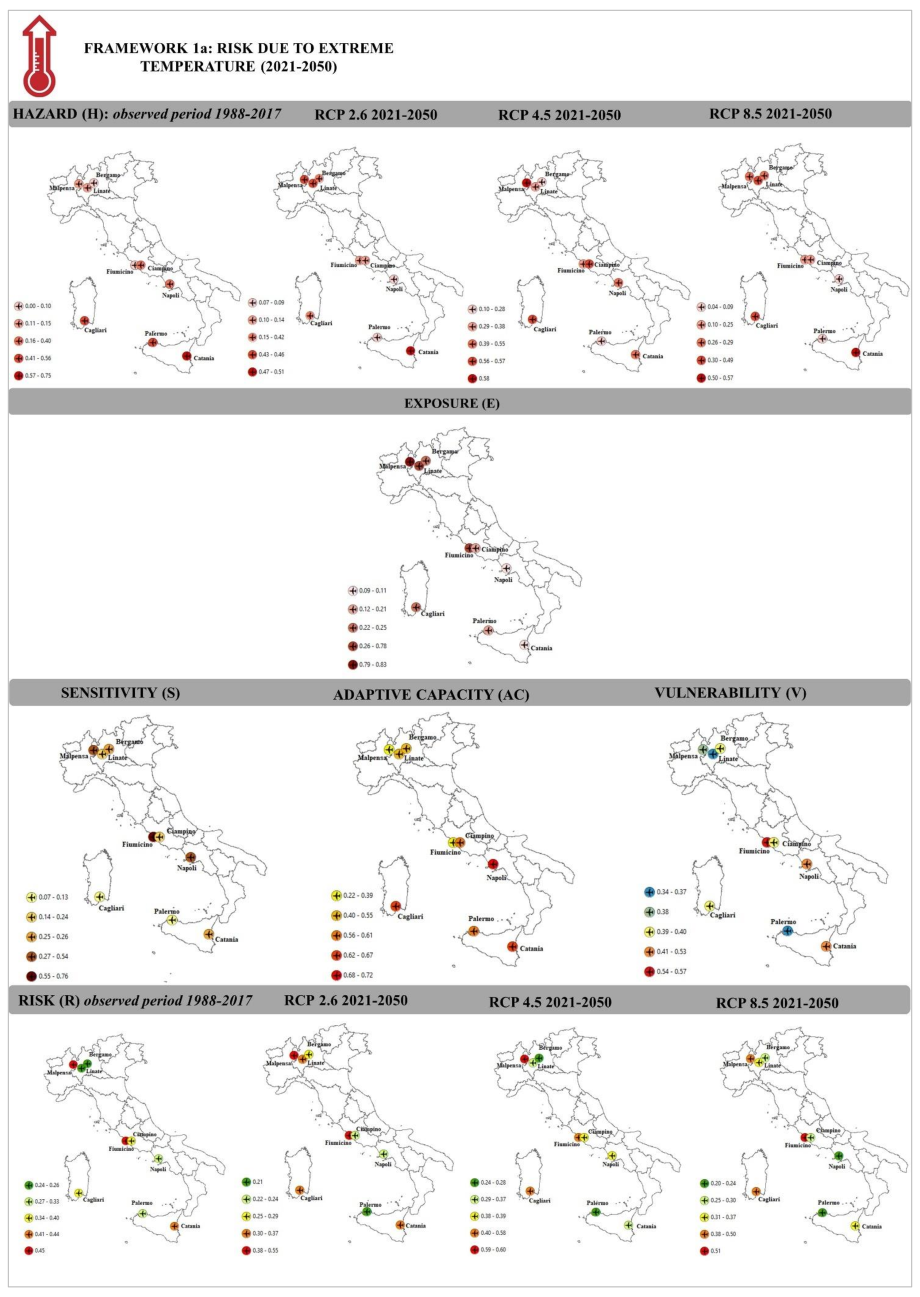

Figure 5: Results obtained from the application of the framework relating to the extreme temperatures. The classes were obtained by the quantile method and correspond to the qualitative classification: "very low", "low", "intermediate", "high", "very high".

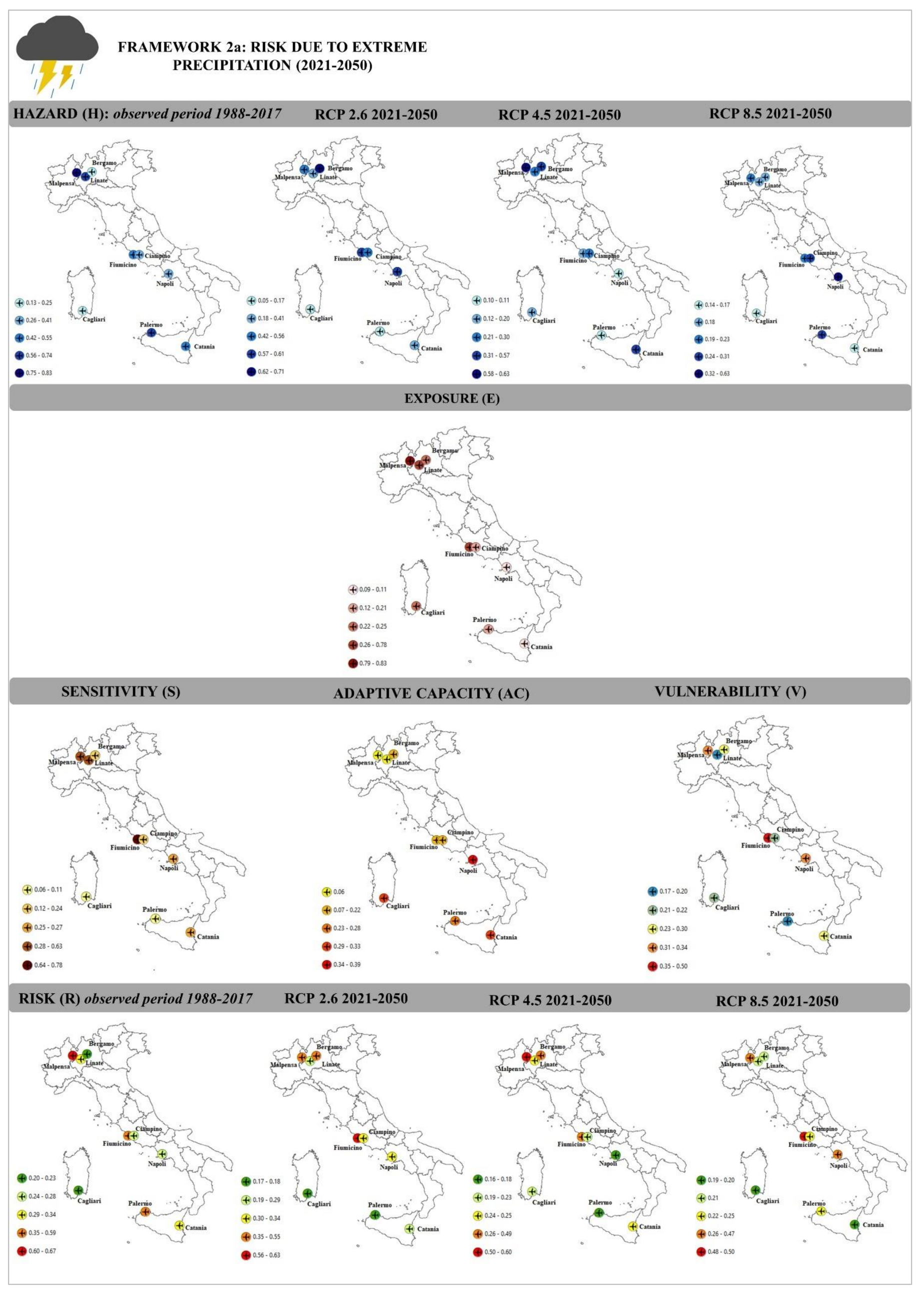

Figure 6: Results obtained from the application of the framework relating to the extreme temperatures. The classes were obtained by the quantile method and correspond to the qualitative classification: "very low", "low", "intermediate", "high", "very high".

Risk associated with extreme temperatures currently is "very high" for Malpensa, Fiumicino and Catania. These same airports, along with Catania, will have to face this risk also in the future in both the most optimistic and the most pessimistic scenarios. As for the risk related to extreme precipitation, it currently appears "high" and "very high" for Malpensa, Fiumicino and Palermo. In the near period, Malpensa, Bergamo and Fiumicino should face this risk in the RCP 2.6 and RCP 4.5 scenario, and Napoli airport in the RCP 8.5 scenario (*Figure 5 and Figure 6*).

An important aspect that emerged from the analyzes is that both for extreme temperatures and for extreme precipitation in all scenarios analyzed, Malpensa and Fiumicino are the most affected airports by climate risk.

The results of the analysis allow to establish priority for actions in climate adaptation planning to be adopted at local level.

4. General remarks and future works

Quantifying the effects of climatic risks on infrastructures is a very complex task due to the limited availability of data, especially those relating to vulnerability (Forzieri et al., 2018). In fact, the datasets often appear fragmented and inconsistent (Mysiak et al., 2016) and this represents a strong limit to carry out robust vulnerability studies and risk analyses. This difficulty also emerged in this study, especially in the collection of information on the characteristics of the airports and on the vulnerability factors. This aspect certainly delineates a margin of uncertainty which is added to the use of climate scenarios.

Further research progress it could involve building an accessible knowledge platform publicly that allows to view information, analyze and extract related data to the case study, in order to integrate of updated information and to extend the analysis to other case studies, also focusing attention on other climatic risks such as sea level rise.

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