CORRESPONDENCE:

Advanced flood risk analysis required

To the Editor — Hallegatte *et al.*[1] present current and future average annual losses or economic risk for various major coastal cities at a global level. But to get a better understanding of these risk levels, sophisticated flood risk analyses at a local, city level will be needed.

For their analysis, Hallegatte *et al.* estimated the return period of flooding on the basis of available information and their own expert assessments. For many cities they used a return period of flooding equal to the defence standard of the region. However, in many countries (such as the Netherlands[2]) a substantial part of the defences are less safe than the standards require. Existing defence standards generally refer to the frequency of failure due to overtopping or overflow. But other geotechnical failure mechanisms, such as those caused by the instability and seepage that occurred in New Orleans[3], can lead to failure when water levels are below the crest of the defences, thereby increasing risk. In addition, various different flood events have different return periods and impacts. For most cities in deltas — examples include Rotterdam, Jakarta and Shanghai — both river and coastal floods can be a threat.

Owing to these factors, the actual protection levels could differ by more than a factor of 10 from the protection standard[4], and the effect on risk will be similar. For a realistic analysis of expected losses, more advanced approaches to flood risk analysis will be needed. These methods must take into account the various defence types, failure mechanisms and flood scenarios[5]. Future risks will also depend on subsidence and sea-level rise, and on how cities develop in flood-prone areas[6].

Most major cities in the developing world and the USA still use relatively low defence standards with 100-year return periods, and Hallegatte *et al.* rightly say that the estimated risk levels will necessitate a higher demand for safety for many cities. Cost–benefit studies for the Netherlands[7] and New Orleans[8] suggest that optimal protection standards for urbanized areas should generally be around 1,000-year return periods or even higher. Only a few fast-growing cities, such as Shanghai, have already adopted these higher defence standards.

Future investments in adaptation to sea-level rise and modification of standards will be high, but are generally small relative to gross domestic product (GDP) and the financial value of damages and risks. For the Netherlands, yearly investments in adaptation of the defences for sea-level rise are estimated to be 0.12% of the current GDP in the year 2025 and 0.14% of GDP if the standards are also heightened[9]. The key question is whether the authorities in the fast-growing delta cities at risk are willing and able to make the much-needed investments in adaptation to sea-level rise, better protection standards and other forms of risk reduction. Various hard (dykes, floodwalls and storm surge barriers) and soft (wetlands and nourishments) measures are available to effectively reduce the flood risks in coastal cities[10]. ❐

References

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Hallegatte *et al.* reply — We agree with Jonkman[1] that local and sophisticated analyses of city flood vulnerability are needed to provide precise estimates of flood risks and operational recommendations on how to improve resilience of coastal cities. In our recent study[2], we estimated how future flood risks could change in 136 coastal cities. To perform such a broad-scale analysis, we had to make numerous approximations and simplifications. As Jonkman stresses, our consideration of existing protection assumes a uniform protection level across the whole city, our flood zones are based on elevation alone and our asset value maps used indirect methods.

We believe it is useful to perform analyses across a range of scales and using a hierarchy of models — from the simple analysis we performed to the highly complex flood models that can only be developed at the city or more detailed level. Because our analysis is simple, it can be applied to a large sample of cities and provide robust and generic results. For instance, we find that because current flood defenses and urbanization patterns have been designed for past environmental conditions, even a moderate change in sea level is sufficient to make them inadequate, increasing flood losses to potentially catastrophic levels. The results of our simplified, global analysis are useful when thinking through the benefits of climate change mitigation or the need for financial support to adaptation. Global loss estimates can help to assess capital needs for the global reinsurance market.

We also identify vulnerability hot spots where local analyses seem to be most urgent. But our analysis does not and cannot answer all questions; it is only a first step. For us, the next phase is to conduct more detailed city-scale risk analyses to provide more precise estimates, which could guide decision-making on responses to climate change. Our analysis is part of a project by the Organisation for Economic Co-operation and Development, which was designed around this idea of several scales of analysis and decision-making. In addition to our recent work[1], there is an earlier global study[3] as well as two case studies of Mumbai[4] and Copenhagen[5]. Ideally, our new global results will help mobilize resources to carry out further analyses at the local scale to support adaptation decisions.

The type of simple analysis we provide is also useful because most detailed analyses have been performed on cities in developed countries, where data, models and human and financial resources are available. For example, these cities usually have spatialized inventories of infrastructure and building