Brief for GSDR 2015

Defensive approaches to extreme weather

*Georgina Mace, University College London**

Key facts / messages:

- Combining scenarios of demographic change with predicted climate change demonstrates that people and their assets will be increasingly exposed to extreme weather over coming decades.
- There are a range of defensive options that can reduce the impact of extreme weather on people.
- While engineering options such as sea walls tend to be the most effective, ecosystem-based options can be more affordable and have positive additional benefits. Hybrid options can combine the advantages of both.

The problem

The following draws on the Royal Society report *Resilience to extreme weather*[1]. The report and further information can be downloaded at royalsociety.org/resilience.

Extreme weather such as floods, droughts and heatwaves has huge human and economic costs at present. The problem is set to get worse not only due to climate change but also because of projected demographic changes such as a growing and aging global population, increasingly located in areas exposed to extreme weather.

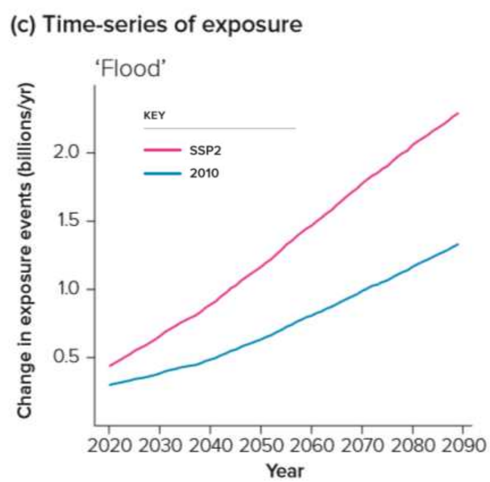

Figure 1[1]: time-series of the estimated change in the number of 'flood'[2] exposure events[3] under the RCP 8.5 emissions scenario with population change under SSP2 (pink-line) and without population change (blue-line).

Modelling work done in the production of the report, based on the RCP 8.5 emissions scenario and SSP 2 demographic change scenario suggests that while climate change may increase the number of 'flood' exposure events by about 3 times by the end of the century, demographic changes will increase that by a further 1.5 times. For 'drought'[4] the number of exposure events was seen to double due to climate change and increase a further 1.5 times due to demographic change. Over-65s are one of the groups most vulnerable to heatwaves. As a result of changes in the climate, the number of

1 The Royal Society (2014) *Resilience to extreme weather*. London: The Royal Society

2 'Flood' is defined as 5-day precipitation totals exceeding the 10 year return level in the historical period (1986 – 2005) as an indicator of future flood events

3 An exposure event is when one person is exposed to an event once in one year.

4 'Drought' is defined as the mean annual maximum number of consecutive dry days, where a dry day is any day with <1mm precipitation

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heatwave exposure events they experience each year could be up to 3 times larger by 2100. However, the combination of climate change and population change could lead to more than 10 times the number of annual heatwave exposure events currently suffered by over-65s.

Steps need to be taken to reduce the current and growing impacts of extreme weather. These include action at the international and national level to reduce the current exposure and vulnerability of people and their assets, as well as to reduce greenhouse gas emissions and adapt to climate change. These steps should go beyond ensuring people can merely cope with extreme weather and ensure they can continue to develop in the face of it. At the local level, the impact of extreme weather can be reduced by physical interventions to defend against the hazard. The remainder of this paper focuses on the evidence regarding types of defensive interventions.

Defensive measures

Physical defensive interventions can be categorised as engineering (using manufactured structures, such as sea walls or wells), ecosystem-based (using natural infrastructure or processes, such as coral reefs or vegetation) or hybrid (using manufactured and natural elements, such as beach nourishment or sustainable agricultural practices).

Information about the effectiveness of defensive options is often not readily comparable. An approximate comparison of options designed to defend against flooding (coastal and river), drought and heatwaves was carried out for the Royal Society report based on expert opinion and relevant literature. The assessment covered the effectiveness, affordability, strength of supporting evidence and additional consequences of the different options.

The assessment suggested that:

- Engineering options are often the most effective in reducing the impact of the hazard. However, they generally have low affordability and few additional benefits. The evidence base for these options is strong.
- Ecosystem-based options are the most affordable and have positive additional consequences, but are often not as effective as other options at reducing the impact of the hazard. The evidence-base to support these options tends to be weaker so there is uncertainty regarding their effectiveness.
- Hybrid options tend to be in the middle in terms of effectiveness and affordability but often have positive additional consequences. The strength of evidence to support these options varies but is generally stronger than that for ecosystem-based options.

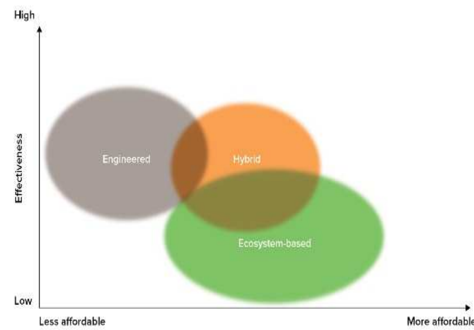

Figure 2[1]: (Figure 13 in report) A schematic chart summarising the results from hazard-specific analysis showing the approximate effectiveness and affordability of different categories of defensive options.

In terms of the six factors that were assessed (see figure 3 below), the analysis also suggested that ecosystem-based options have more positive additional consequences that engineering options, while hybrid approaches appear to have the most positive consequences.

There is evidence that social and behavioural options can be effective in reducing the impact of extreme weather and can increase the effectiveness of physical options[5].

[5] IPCC 2014 *Summary for policymakers.* In: *Climate Change 2014: Impacts, adaptation, and vulnerability. Part A:Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change* (ed. Field, C B, Barros V R, Dokken D J, Mach K J, Mastrandrea M D, Bilir, T E, Chatterjee,M, Ebi, K L, Estrada, Y O, Genova, R C, Girma, B, Kissel, E S, Levy, A N, MacCracken, S, Mastrandrea, P R & White L). Cambridge and New York: Cambridge University Press.

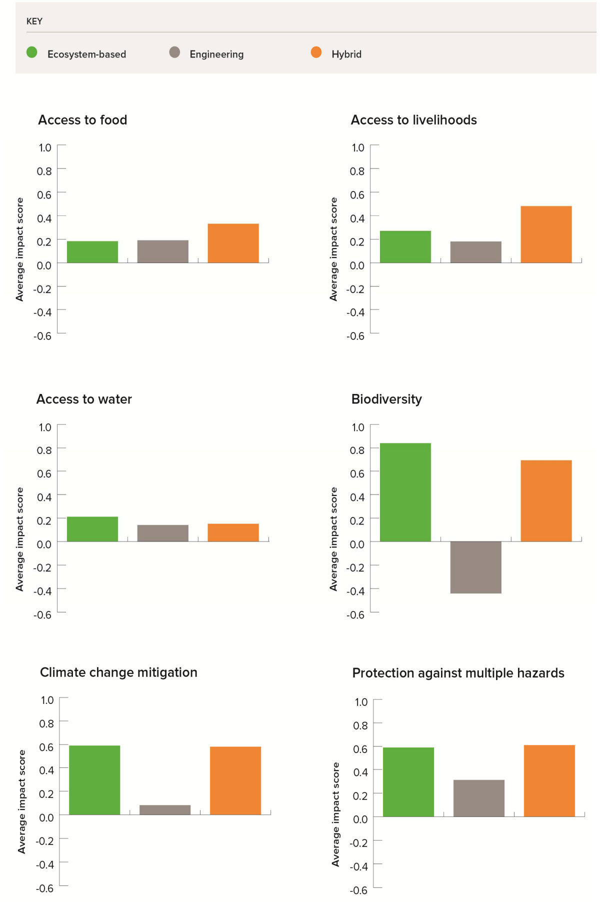

Figure 3[1]: Additional consequences of ecosystem-based, engineering and hybrid options. The average impact score of the different categories of defensive options, across all types of extreme event considered in the report analysis (coastal and inland flooding, drought and heatwave), on each additional consequence assessed.

Conclusions

Decisions about interventions to defend against extreme weather need to take into account the specific context in which they would be implemented. However, the analysis suggests that hybrid and ecosystem-based defensive options should be considered alongside engineering options. The evidence also suggests that a portfolio of options is likely to be more effective at providing protection from a range of hazards with different intensities and scales. It is particularly effective to deploy this range of interventions as part of a comprehensive resilience strategy that considers the whole system and timescales over decades.

There is generally strong evidence of the affordability and effectiveness of engineering defensive options. Much work is currently being done to test ecosystem-based and hybrid approaches[6]. However, further evidence is still needed to improve decision-making, build confidence in these options, and allow them to be compared to engineering options.

Defence against extreme weather alone won't be sufficient to ensure people's quality of life in face of increasing extreme weather. It is a first step towards protecting lives and assets but wider measures will need to be taken at international, local and national levels to reduce exposure and vulnerability extreme weather, as well as to mitigate and adapt to climate change.

References

IPCC 2014 *Summary for policymakers.* In: *Climate Change 2014: Impacts, adaptation, and vulnerability. Part A:Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change* (ed. Field, C B, Barros V R, Dokken D J, Mach K J, Mastrandrea M D, Bilir, T E, Chatterjee,M, Ebi, K L, Estrada, Y O, Genova, R C, Girma, B, Kissel, E S, Levy, A N, MacCracken, S, Mastrandrea, P R & White L). Cambridge and New York: Cambridge University Press.

Spalding, M D, McIvor, A L, Beck, M W, Koch, E W, Möller, I, Reed, D J, Rubinoff, P, Spencer, T,Tolhurst, T J, Warmsley, Ty V, van Wesenbeek, B K, Wolanski, E & Woodroffe, C D 2014 *Coastal Ecosystems:A Critical Element of Risk Reduction*. Conservation Letters, 7(3), 293–301. (DOI:10.1111/conl.12074).

The Royal Society (2014) *Resilience to extreme weather.* London: The Royal Society

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[6] See examples in Spalding, M D, McIvor, A L, Beck, M W, Koch, E W, Möller, I, Reed, D J, Rubinoff, P, Spencer, T,Tolhurst, T J, Warmsley, Ty V, van Wesenbeek, B K, Wolanski, E & Woodroffe, C D 2014 *Coastal Ecosystems:A Critical Element of Risk Reduction*. Conservation Letters, 7(3), 293–301. (DOI:10.1111/conl.12074).