# Policy Brief: How cost-effective are Nature-based Solutions to climate change adaptation?

Identifying and implementing robust adaptation approaches that are cost-effective and build resilience across a range of potential future climates is critical. To date, the dominant approach has been a mix of direct engineered interventions such as sea walls, levees or irrigation infrastructure and indirect interventions such as early warning systems and awareness raising[1]. However, there is **growing recognition that nature-based solutions — i.e. restoration and protection of natural habitats— when applied strategically and equitably can not only safeguard biodiversity and ecosystem services but also help people adapt to the effects of climate change[2].** NBS include the restoration of coastal ecosystems to protect communities from storm surges and erosion[3-6], agroforestry to stabilise crop yields in drier climates[7,8], and forest restoration in headwaters and riparian zones to secure and regulate water supplies and protect communities from flooding, soil erosion, and landslides[9-11].

But how cost-effective are NBS compared to alternative adaptation approaches? A recent semi-quantitative review commissioned by the Royal Society (2014) compared NBS (focussing on ecosystem-based adaptation), hybrid and engineered approaches to reducing risks to people from extreme weather events (coastal and riverine flooding, heatwaves, drought) using a combination of literature and expert scores and opinion. The study compared the effectiveness of each option (encompassing both magnitude of the event against which the intervention can be effective and spatial scale over which it is effective) versus its affordability (combining both initial and long-term [to 2050] costs of intervention) (Fig. 1). It also scored intervention with respect to the number of co-benefits it brought (Fig. 2).

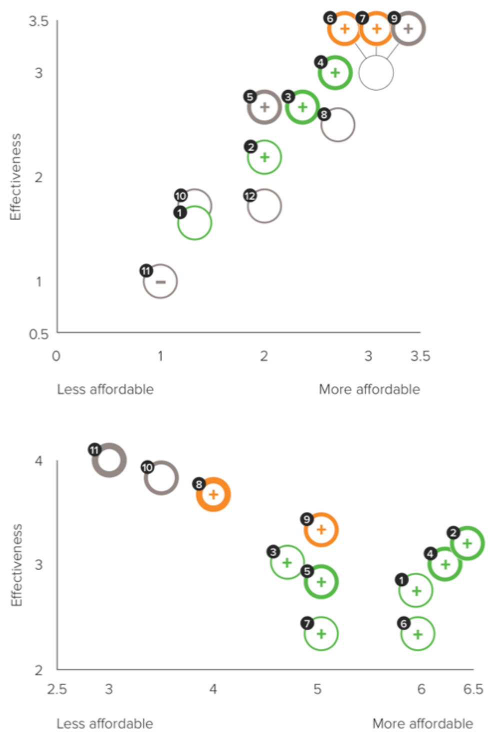


**Fig. 1** Cost-effectiveness of NBS (green), engineered (grey) and hybrid (orange) adaptation approaches to **a, drought** and **b, coastal flooding.** Strength of available evidence increases with thickness of circle lines; signs within circles denote whether overall there are positive, negative or no co-benefits (e.g. ecosystem services) of the approach; numbers within circles refer to the type of adaptation approach. **a, Drought adaptation**: (1) removal of 'thirsty' invasive plant species, (2) reforestation, (3) forest conservation, (4) agroforestry, (5) breeding drought resilience crops and livestock, (6) sustainable agroecosystem management practices, (7) soil and water conservation, (8) reservoirs, points and other water storage, (9) wells, (10) irrigation, (11) inter-basin water transfer and (12) waste water re-cycling. **b, Coastal flooding adaptation**: (1) maintenance of natural reefs (coral/oyster), (2) mangrove maintenance, (3) mangrove planting and re-establishment, (4) maintenance of saltmarshes, wetlands and intertidal ecosystems, (5) creation of saltmarshes, wetlands and inter-tidal ecosystems, (6) maintenance of other coastal vegetation, (7) coastal re-vegetation/ afforestation(above inter-tidal zone), (8) beach and dune nourishment, (9) artificial reefs (and/or substrates for reef replenishment), (10) dykes, levees, (11) coastal barrages. ©The Royal Society 2014.

The assessment found that engineered approaches have immediate, measurable impacts and are particularly effective in reducing the impacts of specific hazards over the short-term. However, they are expensive and deliver few if any co-benefits. In contrast, NBS is affordable, provides a wide range of ecosystem services and offers protection from multiple hazards, which is important as hazards seldom occur in isolation but can take place simultaneously or in a cascade. For example, coastal forests can protect against coastal and inland flooding, strong winds, and high temperatures, whilst providing a range of ecosystem services and supporting more diverse livelihoods. In contrast to engineered approaches, NBS also involve and benefit local people, can be more adaptive to new conditions, and is less likely to create a false sense of security. Set against these merits, NBS tend to be less effective than engineered structures over the short-term (i.e. effects are hard to quantify and can take time to manifest themselves), can take up larger areas of land, and involve the use of ecosystems that are themselves vulnerable to climate change. Meanwhile, hybrid approaches are intermediate in terms of effectiveness and affordability, but often have positive additional consequences. For example, two of the most affordable and effective hybrid options against drought are using 'sustainable agro-ecosystem management practices' and 'soil and water conservation'. These are bundles of separate, mutually reinforcing, small interventions, involving some NBS, changes to agricultural practices and low-tech engineering, which can be tailored to local contexts. Overall, hybrid approaches have the most positive consequences, and are marginally higher than ecosystem-based approaches for all the factors considered in the assessment (Fig. 2).

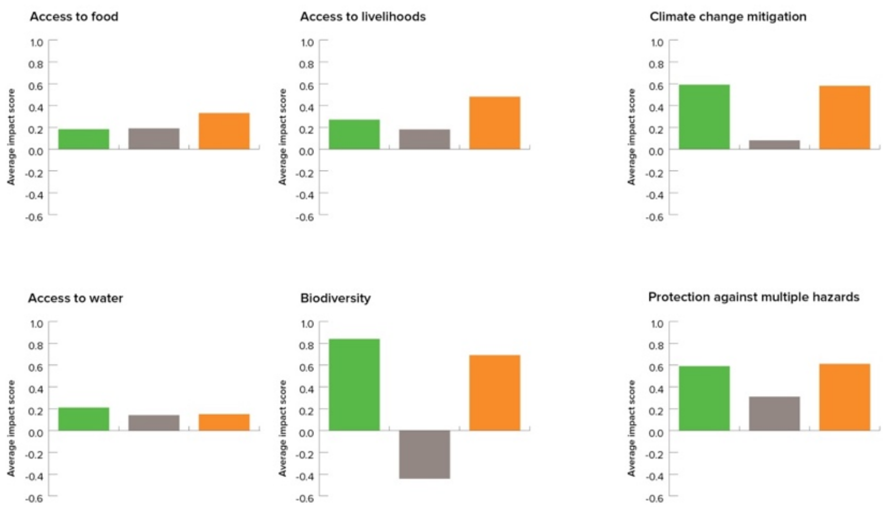


**Fig 2. Additional consequences of different categories of adaptation options** Average impact score of nature-based (green), engineered (grey) and hybrid (orange) options, across all types of extreme event considered, on each additional consequence assessed. ©Royal Society 2014

The assessment concluded that despite the shortcomings of NBS and in the face of uncertainty around both risks and effectiveness, **NBS is a 'low risk' or 'no regret' option that provides more positive consequences than those that are engineering-based**. On the basis of the assessment, policy recommendations were to: *(1) consider defensive options beyond traditional engineering approaches (e.g. NBS and hybrid approaches that offer additional benefits to people) including the conservation of natural ecosystems which are difficult or impossible to restore; and (2) monitor and evaluate the effectiveness of interventions, in particular of NBS, and apply the results to improve future decision-making.*

**References:** **1.** The Royal Society. Resilience to extreme weather (2014). **2.** Jones et al. Harnessing nature to help people adapt to climate change. Nat. Clim. Chang. 2, 504–509 (2012). **3.** Stein et al. Preparing for and managing change: climate adaptation for biodiversity and ecosystems. Front. Ecol. Environ. 11, 502–510 (2013). **4.** Das & Vincent. Mangroves protected villages and reduced death toll during Indian super cyclone. Proc. Natl. Acad. Sci. U. S. A. 106, 7357–60 (2009). **5.** Temmerman et al. Ecosystem-based coastal defence in the face of global change. Nature 504, 79–83 (2013). **6.** Arkema et al. Coastal habitats shield people and property from sea-level rise and storms. Nat. Clim. Chang. 3, 913–918 (2013). **7.** Mbow et al. Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. Curr. Opin. Environ. Sustain. 6, 8–14 (2014). **8.** Lasco et al. Climate risk adaptation by smallholder farmers: the roles of trees and agroforestry. Curr. Opin. Environ. Sustain. 6, 83–88 (2014). **9.** Ebert et al. Floodplain restoration along the lower Danube: A climate change adaptation case study. Clim. Dev. 1, 212–219 (2009). **10.** Mueller et al. Estimating the value of watershed services following forest restoration. Water Resour. Res. 49, 1773–1781 (2013). **11.** Huang et al. Forest restoration to achieve both ecological and economic progress, Poyang Lake basin, China. Ecol. Eng. 44, 53–60 (2012).