Does infrastructure need an antidote?

How are complex societal needs going to be satisfied in a resource constrained and environmentally sensitive world? The answer may not rest with the developed world's traditional reliance on single risk, fixed asset, engineering infrastructure. Instead, more distributed systems may be far more effective. David Arscott, Director of PyTerra Ltd, explains the benefits of this alternative approach.

Caption: How can we best exploit and manage distributed infrastructure systems?
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Twenty years ago, if you were a flood authority and you asked an engineer to design a solution to town centre flooding, they would most probably design a concrete and steel flood barrage which sits there quietly until there is a flood. Not only does this take a long time to plan and build, and not only is this expensive (in Carlisle it cost £38m), but this does not deliver value when not on flood duty and this does not always work (as seen in Carlisle, 2015). Is there an alternative?

One approach is to focus on creating solutions that use the power of distributed resources to deliver multiple benefits, in contrast to fixed assets dedicated to a single issue risk. In this way, solutions are no longer the domain of one entity, such as a water company, but evolve in response to a changing environment by engaging multiple land owners, solutions providers, stakeholders, funders and customers. This approach reflects the priorities of the Government's planned Environmental Land Management scheme (ELMS) as the basis for farm payments, moving away from funding food production and towards paying for environmental services and benefits.

For example, upstream farmers could provide a synchronised network of reservoirs which can capture flood water and treat agricultural run-off using associated wetlands. Downstream communities would have their flood risk reduced as a result and insurance companies would be less exposed to claims. When not on flood duty or used for irrigation, the reservoirs and wetlands would slowly release treated water into the river, helping reduce the treatment duty on abstracted water by the local water company while enhancing local biodiversity.

One of the main challenges is how the complex, many-to-many relationships of risks and solutions can be managed 'in the field'. This has been the subject of pilot projects by PyTerra between 2013 and 2017.

Modelling distributed solutions

In our pilot projects, undertaken with consultants WSP and with support from the Environment Agency, we demonstrated how distributed solutions can be successfully managed in almost real time.

The team modelled a synchronised network of upstream flood retention areas and developed digital technologies to manage them. These included programs for both rapid flood prediction and flow optimisation across retention areas. Testing was carried out using historic rainfall and flood data from three locations: Wokingham, North London and South London.

The flood prediction tool demonstrated good results (up to 87% accuracy even for this proof-of-concept model) within minutes rather than hours (as provided by existing methods). The tool takes into account where the rain is falling and when it will impact on a river. It uses machine learning technology, ideally absorbing 20 years of historical rainfall and flood data at read intervals of 15 minutes, but capable of delivering robust results with only three years of data.

The optimisation tool uses Least Mean Squares optimisation techniques to create adaptive software which can quickly identify how to distribute water between upstream storage ponds and a river to achieve optimal emptying and refill times. Not only does this provide a more effective flood solution to traditional infrastructure and manual methods, it also reduces the size of retention volumes needed, as well as allowing the system to reset itself in preparation for the next storm.

One of the result highlights is on the Emm Brook in Wokingham, which has an average water level of 0.47m, with minor flooding at 1.20m. In 2007 it reached 2.33m, causing significant local damage. In the pilot study, three networked retention areas were designed upstream of Wokingham, and even with the extreme conditions of 2007, flooding was shown to be fully mitigated.

From ‘big and simple’ to ‘big and sophisticated’

The UK is continuing to experience the impact of increasing global water risks. Rather than ‘big and simple’ solutions we need ‘extensive and sophisticated’ solutions. We need to start running pilot studies at scale which can test these assumptions. There will need to be answers about ownership, liability and finance. There will need to be the use of digital marketing techniques to engage multiple players in an integrated marketplace, allowing each player to be curated throughout the development and operational process. Financial and insurance services will need to innovate in order find ways to support these new types of markets. Nevertheless, the concept of distributed solutions, brought to life through the use of systems technology, may be just the answer to increasingly complex and distributed environmental challenges.