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Natural Flood Management

Adopting ecosystem approaches to managing flood risk

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Executive Summary

Nature is a key ally in meeting the challenges of climate change mitigation and adaptation. Working with nature can provide sustainable cost-effective solutions to many of the impacts of climate change. 'Natural flood management' is when a whole catchment approach is taken to managing flood waters, through managing soil, wetlands, woodlands and floodplains to retain water strategically at times of flood risk. Natural flood management has gained recognition in many countries as a viable and cost effective approach to flood risk management, with extensive projects across Europe and further afield that have restored peat bogs, planted riparian woodlands, restored and created new wetlands, re-profiled rivers and their floodplains to hold back floodwaters.

However natural flood management is an approach that is virtually unknown in Ireland and has not been widely discussed in any relevant spheres here, despite the growing problem of widespread flood damage in recent years and forecasts of worse to come. There have been no trials or pilots of catchment based approaches to flood management in Ireland, despite evidence that natural flood management can be an effective means of significantly reducing flood peak; that this approach is significantly cheaper than other approaches in use; and that there are multiple additional benefits to the natural environment and climate change adaptation.

In recent decades urban and agricultural expansion and intensification, often onto historic floodplains, has resulted in the loss of capacity of floodplains to attenuate flooding. Dredging continues on many river channels despite its tendency to exacerbate downstream flooding. Agricultural land use changes have reduced the permeability of soils and increased paving has reduced permeability in urban areas. Drainage and infilling of wetlands has resulted in loss of natural flood water storage basins.

Now, in response to increasing frequency of extreme rainfall events and consequent flooding that is happening because of climate change, Ireland needs to urgently develop and implement measures to reverse the decline in natural flood attenuation. Exclusive reliance on hard engineered flood protection works no longer represents the optimal approach to managing flood risk. Instead, combinations of catchment wide measures are now evidenced as good international practice.

This report examines the potential benefits to be gained from various natural flood management measures and makes recommendations on how these could be implemented here. These include peat bog restoration, woodland creation, incentivised agricultural land use changes, floodplain restoration, wetland protection, and managed coastal realignment.

Case studies are presented of projects which have successfully implemented natural flood management, including 'Slowing the Flow' project in North Yorkshire and the 'Room for Rivers' in the Netherlands. In examining case studies of for this report, a number of key indicators of success have been identified. These are: detailed hydrological modelling on a catchment wide scale; strong community involvement in addressing flood risk and assessing the range of solutions; and involvement of a range of interests and state agencies in recognition of the wider environmental co-benefits of natural flood management.

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1. Introduction

Nature is a key ally in meeting the challenges of climate change mitigation and adaptation. Ecosystem based approaches to climate change adaptation can provide sustainable cost-effective protection against many of the impacts of climate change. In this report, we assess the potential role of using ecosystem based approaches to flood risk management in Ireland. Collectively termed 'Natural flood management', this approach works on a catchment wide scale to restore the natural ability of the landscape to regulate water flows and reduce flood risk. The integrated approach to flood risk management has many additional benefits in terms of economic viability, nature conservation, water quality and amenity, thus delivering multiple benefits to society.

Climate change and Flooding

Flooding and coastal inundation was widespread across Ireland in the winders of 2013/2014 and 2015/1016. The socio-economic impacts of both river flooding and coastal flooding have been significant. Ireland has already seen a doubling in the likelihood of extreme flooding in last 100 years[i]. With a warming climate, rainfall extremes are projected to increase here, particularly during winter. The likelihood of the wettest winter has doubled since 1850[ii]. Damaging floods in Ireland could be eight times more frequent because of climate change[iii]. Extreme flood events, currently expected once in every 50 years, likely to occur once every 10 years by the second half of this century[iv], [v].

The standard conventional approach to flood risk management is construction of structural defences to protect at risk areas. Because of the rise in extreme precipitation events and the increased risk of flooding associated with climate change, ever larger concrete flood defences in towns and cities are both unsustainable and undesirable. In order to respond to this situation, despite uncertainty of the severity and timing of increases in flood risk, Ireland must plan and implement adaptation actions across all levels, from local communities to local and national government. Because of the extensive nature of NFM approaches, participation of local communities in designing and implementing NFM is crucial. In some of the case studies, NFM approaches have been led by communities as a preferred alternative to traditional hard engineering approaches.

How River Flooding Occurs

When the flow of water in a river channel exceeds the capacity of the channel it spills over the natural or artificial embankments. Natural flood plains hold the excess water during flood events. Flooding is a natural process which for millennia has been a valuable process that enriches land with nutrient rich alluvial sediment and enhances fertility. The fertility of the Nile floodplain, which contributed to the evolution of early cultures there, was dependant on frequent flooding. However, we are more familiar today with the capacity of floodwaters to cause damage to homes and businesses and associated economic and sociological effects. 'Economic flooding' is a term applied to flooding which causes damage to property or crops resulting in economic losses.

Flooding can be intensified or abated by the characteristics of the river channel itself and by the characteristics of the surrounding landscape. Land use changes have tended to increase flood risk by altering the flow of water in the landscape: reducing the permeability of land surfaces throughout the catchment; physically changing landscape features and thus flow pathways; removing wetlands; and by severing the connection of rivers with their floodplains.

2. Land Use & Flood Risk Management

Speeding up the flow

Land use throughout a catchment can act to speed up or slow down the length of time and degree of dissipation of water as it moves from land in to river channels. 'Flood peak' is when the highest volume of water is flowing through a river basin at the peak of a flood. Flood peak is often represented as a graph of the volume of water over the time it takes to move through a catchment. When flood waters reach the river channel in a short period of time there is an increase in flood peak. Conversely when water movement is slowed down so that the discharge occurs over a longer period of time, there is a reduction in flood peak.

Impermeable surfaces such as concrete paving, roads, housing, car parks, normally associated with urban and suburban development, all reduce the amount of time it takes for precipitation to enter river channels. In this way, a significant increase in impermeable paving increases the risk of flooding by increasing 'flood peak' – when a large amount of water takes a small amount of time to reach a river channel. Similarly, compacted soils on agricultural land reduce permeability and can contribute to an increase in flood peak. Soil structure, management and saturation influences permeability.

Woodlands and semi-natural land cover generally reduce flood peak by adding surface roughness and increasing soil permeability, deforestation and land clearance can increase flood peak. Conversely, bare soils or minimally vegetated soils, such as those associated with tillage or other intensive farming, have little to assist the infiltration of water in to the soil. Soils that have been compacted by agricultural intensification are also less permeable. However in some cases the drainage of soils means that they are less likely to be saturated in periods of heavy rainfall and the soil moisture deficit results in greater absorption of rainwater.

In addition to the land use and management in the wider catchment, physical structure of the river channel itself also determines the speed of flow and thus the flood peak. Traditional approaches to flood management involve speeding up the movement of water through river channels. Arterial drainage (mainly dredging of rivers) is when a river channel is artificially widened and deepened so that more water will pass through the channel more rapidly. Dredging has been widely practiced in Ireland since the 1950's. According to a 2015 report by the Office of the Comptroller and Auditor General[vi] "*The principal objective of arterial drainage schemes carried out in Ireland by the Office of Public Works (OPW) was to bring about a long term improvement in agricultural incomes in river catchments. The work carried out on schemes was designed to allow landholders to install field drainage which reduces waterlogging of land and enables it to carry more livestock or produce higher crop yields. Schemes also have the effect of reducing both the incidence and duration of flooding*". While dredging carried out for agricultural purposes can help to reduce the depth of local flooding, commonly on agricultural land, by increasing the volume that passes through a channel at any given time, it increases flood peak and thus exacerbates downstream flooding. The same report presents a financial argument that the benefits likely to be derived from carrying out arterial drainage are "*likely to be only marginally greater than the costs*".

Slowing the flow

Topography, soil type and land use all determine the speed at which water runs off the land and in to river channels, thus acting together to influence the propensity of a river to flood. The presence of wetlands in the catchment and the functioning of natural floodplains provide storage for excess water that might otherwise contribute to flooding. As our understanding of landscape scale hydrological processes has improved in recent decades, good practice for managing flood risk has also evolved to incorporate catchment wide land use and management which slows down the flow of water through the catchment and thus reduces flood peak.

In addition to natural features such as wetlands, woodlands and heaths, soft engineering works are also being effectively deployed to slow the flow of water on a catchment wide scale and in this way reduce flood risk. Slowing the rate at which water moves through the upper reaches of a catchment helps to reduce flood peak and thus lessens the flooding that occurs in communities, towns and cities further downstream. A multitude of strategically placed small soft engineering works, such as woody debris damns which hold back floodwaters, have been found to be a cost effective approach to reducing flood peak. The following section presents summaries of the main approaches to slowing the flow that are relevant to flood management in Ireland.

3. Natural Flood Management

Natural flood management ('NFM') is an approach to managing flooding which works with natural hydrological processes throughout the catchment to store flood water temporarily during flood events. Natural flood management involves managing the pathways of water and enhancing the capacity of features throughout a catchment to store floodwater.

Natural flood management measures include

- peatland restoration for flood attenuation;
- woodland creation to impede the flow of water and increase infiltration;
- managing wetlands to store flood water;
- re-connecting rivers with their floodplain;
- reinstatement or creation of water storage features in floodplains;
- creation of new features to temporarily store water;
- opening up land to flooding;
- Sustainable Urban Drainage Systems (SUDS);
- Managed coastal realignment with saltmarsh and mudflat restoration

Detailed catchment scale hydrological modelling is a necessary precursor to the design and implementation of natural flood management. This is so that the impact of all potential measures on flood peak can be modelled and then strategically selected and located to maximise flood alleviation based on catchment wide scale. Even with good modelling, the impact of various natural flood management measures on reducing flood peak can be challenging to predict and monitor, especially for measures implemented in the upper reaches of catchment.

Natural flood management has gained recognition as a viable and cost effective approach to flood risk management. Additional benefits to biodiversity, climate change mitigation, and water quality, make it a holistic approach to land management that increases the resilience of communities and landscapes to the multiple challenges climate change. An inclusive approach in which communities and a range of public bodies have been involved from the outset of the projects, in some cases leadership from the ground up, has been an indicator of success of many natural flood management projects.

There have been no trials or pilots of catchment based approaches to flood management in Ireland, despite evidence that natural flood management can be an effective means of significantly reducing flood peak; that this approach is significantly cheaper than other approaches in use; and that there are multiple additional benefits to the natural environment and climate change adaptation. NFM is an approach that is virtually unknown in Ireland and has not been trialled, piloted or widely discussed in any relevant spheres here, despite the growing problem of widespread flood damage in recent years.

A number of studies have demonstrated that many small interventions throughout the catchment can act to collectively reduce flood peak and thus lower the probability of flood damage in any given year. The implementation of many different types of interventions together is considered to have the greatest benefit to flood management. NFM works best in combination with other flood management measures.

Natural Flood Management Measures

Peatland Restoration for Flood Attenuation

Blanket bogs in the uplands are made up of wet peat soils which are, in their healthy state, saturated for most of the year. Because they are already saturated, upland blanket bogs do not contain any great potential for the storage of water in flood risk events. Drainage networks in upland blanket bogs act to lower the water table, hence increasing soil moisture deficit and increase the water storage potential of these environments. However, drainage channels in upland peat bogs is in direct conflict with conservation management of peat bogs and negates the biodiversity and carbon storage functions of these habitats. A healthy peat bog can also attenuate flooding by slowing the movement of surface and sub-surface water from heavy rainfall events because of the rough surface vegetation. Peatlands with tall woody or coarse vegetation, many small surface depressions and pools and with little surface channel connectivity will tend to hold surface water for longer, so delaying water discharge to downstream channels[vii]. This is a positive impact for reducing flood peak. Drainage can also speed up the movement of water from the peaty upper reaches of a catchment and thus increase flood peak.

The Scottish Environment Agency Flood Management Handbook states that "*while the effects of modifying drainage systems are inherently complex, there is increasing evidence that upland drainage blocking can, when targeted and delivered appropriately, create more stable water tables that are better able to respond to extreme events and achieve reasonable reductions in flows*."

Raised bogs which occur in lowland landscapes, generally in the middle reaches of a catchment, have a complex relationship with floodwaters. These midland raised bogs have mostly been drained and harvested for milled peat and for turf, so that only a tiny proportion of these raised bogs remain intact. Of those that remain, many have had drainage channels cut through them to dry out the peat in preparation for harvesting. While this is ecologically detrimental because it removes the conditions that characterise the bog and sustain the many flora and fauna that depend on these bogs, it is not necessarily negative for flood storage capacity. As with blanket bogs, drainage increases the soil moisture deficit of the peat surface, thus enhancing soil water storage capacity. However the channels also speed water flow to channels[viii] thus exacerbating flooding.

This demonstrates that each wetland has unique hydrological characteristics and the extent to which each attenuates flooding will need to be assessed through detailed measurements and hydrological modelling. While evidence is difficult to collate because of the complexity of landscape scale water movement and variability of such a wide range of factors, and it has been suggested that peatland restoration may not provide significant peak flow benefits during extreme floods, but can improve flood warning times and therefore reduce flood damage.

Implementing peatland restoration for flood attenuation

To assess the benefit of peatland restoration at any given site hydrological modelling followed by implementation of small scale peatland drain blocking will be necessary. Understanding small scale alterations to a peatland site combines will help to understand the dynamics of the bog in its catchment. In Ireland, **drain blocking** on peat bogs has been carried out for conservation purposes, although the impact of drain blocking on flood attenuation has not been studied here. A good deal of work has been carried out in the UK in to the methods of drain blocking and the impact on flooding[ix], [x] .

Woodland creation

Woodlands can mitigate flood risk in a number of ways. As anyone sheltering from rain under a tree will know, trees can intercept rainfall. They also maintain an uneven ground surface which slows water and helps infiltration to the subsoil. The high levels of organic matter in woodland soils also increase the water storage capacity of the soil itself. In slowing the conveyance of water woodlands can reduce flood peak.

The extent to which woodlands attenuate flood risk is dependent on its species composition and management. For example, the interception of rainfall is greatly reduced in broadleaved woodlands in winter when the trees are void of their leaves. However, **semi-natural woodlands** with limited management are thought to offer greater scope for flood reduction than more managed plantation forests[xi]. One study shows that soil infiltration rates are up to 60 times higher where young native cross slope woodlands were present compared to adjacent heavily grazed pasture[xii].

Woodland creation also has greatly differing impacts on flood attenuation depending on the location in the catchment. **Floodplain woodland** is thought to offer the greatest potential for downstream flood mitigation[xiii] Woodlands planted in parts of the catchment where soils generate rapid runoff in to streams, such a heavy soils prone to waterlogging, can also be beneficial for flood attenuation. As with all natural flood management measures, hydrological modelling of the soils, land use and pathways of water movement in to streams is essential when designing and locating woodlands for flood attenuation.

Woody damns, also referred to a 'leaky woody damns; and 'logjams' are a particularly interesting approach to holding back water in the upper reaches of a catchment. Log jams or leaky woody damns allow normal stream and river flows in no flood risk times but when the volume of water passing through the steam increases they obstruct the flow and trigger the stream or river to flood. When this is implemented in forests in the upper reaches of a catchment the backup of water behind these structures will act as additional temporary storage. When many of these structures are in place, the aggregated flood storage can contribute to reducing flood peak.

Additional benefits of woodland creation

Woodlands have a range of other benefits relating to climate change adaptation and mitigation. Woodlands can help mitigate against climate change when managed as a permanent landscape feature. Riparian woodlands generally help to improve water quality by absorbing diffuse nutrients which arise primarily from agriculture and plantation forestry [xiv], as well as trapping sediment from running off land in to waterways. Sediment becomes a problem when too much of it enters rivers, and as the amount of sediment arising from erosion increases with heavy rainfall, trapping sediment is one of the challenges to be addressed in climate change adaptation. With increased frequency and severity of precipitation events likely to arise from climate change, this is an important climate change adaptation measure. Conversely, artificial fertilisers applied for forest management can result in nutrient pollution to waterways and soil disturbance from forest management can cause sedimentation.

Implementing woodland creation for flood attenuation

In England, the Forestry Commission has worked with the Environment Agency to implement a 'Woodlands for Water' scheme. Landowners are incentivised with RDP payments to target planting to reduce flood risk and/or diffuse pollution. This payment for landowners is additional to the existing grant offered for afforestation under the national afforestation plans. This resulted in 1,857 ha of woodland creation across England under the previous English Woodland Grant Scheme and applications for 180 sites totalling 1,300 ha under the first year of Countryside Stewardship.

Recommendations

In Ireland, the Forest Service must consider offering an additional payment on top of existing afforestation grants, perhaps via the '**Woodlands for water**' scheme, to create woodlands in areas where hydrological data indicates that flood alleviation benefits would be delivered.

In addition, pilot schemes for tree planting for flood alleviation are needed in Ireland, which incorporate detailed hydrological modelling component. This would further our understanding of tree planting for flood alleviation and water quality and help to demystify the approach. Research and pilot schemes would ideally include the varying contribution of different species mixes and management systems, their location in the catchment, and comparison with flood alleviation services of other habitat types.

Agricultural Land Management

Heavily engineered flood alleviation and flood protection works has been the focus of flood management to date. However the root causes of flooding – land management and loss of functional floodplains – are rarely addressed. Agricultural intensification, in particular in floodplains, can reduce the ability of land to absorb and slow floodwaters, thus exacerbating flooding downstream. Both soil compaction and the removal of semi-natural habitats such as wetlands, woodland, scrub and hedgerows reduces the ability of land to absorb or store water and speeds up overland flow in to river channels.

On intensively managed land, **soil compaction** through sustained use of heavy machinery can reduce the absorptive capacity of soil and thus increase rates and speed of overland flow. Bare ground in winter can accelerate runoff simply by the lack of vegetation which creates surface roughness. Leaving soils un-vegetated in winter also results in soil erosion can negatively impact the productivity of soils.

Throughout Ireland **field drains** have been put in place to dry out the land and improve agricultural productivity. The cumulative impacts of field drainage over a sub-catchment can act to accelerate runoff in to streams, overall speeding up the time it takes for large volumes of water to enter river channels and thus increasing flood peak. In catchments where this is found to contribute to flooding, breaking field drains to restore wet grassland and even to re-create wetlands in these areas to attenuate flood peak should be considered. This will result in lower agricultural productivity in those locations. In other fields where losing productivity is not desirable, integrated drainage to link runoff to features such as wetlands or to engineered flood storage areas could attenuate flooding. A small scale catchment trial in which some fields are helped to revert to wet grassland and others have the drainage altered to steer it elsewhere could help to understand the potential impact of altering agricultural land drainage to reduce flood peak.

Planting hedges along the contour of a field can also help to intercept runoff, in addition to the roots of hedgerow trees aiding infiltration of water. As with other natural flood management measures, hedgerow planting will only achieve flood alleviation service if targeted at the right locations, in this case planting along contour lines, on specific slopes where runoff should be targeted, and in floodplains.

Similarly, **agroforestry**, by incorporating tress in to productive agricultural land as both a crop and a shelter for stock, has been shown to greatly increase soil water infiltration capacity, thus slowing run-off and contributing to flood attenuation. Evidence shows that there are significant merits for reducing local flood risk by having fenced-off tree areas in silvo-pastoral settings[xv].

Agricultural intensification on floodplains can make the soil more compact and reduce the capacity of soils to absorb floodwater. When drainage channels are dug in to the floodplain to dry out the land and thus improve agricultural productivity, water will move more rapidly from the floodplain in to the river channel. Other activities generally associated with agricultural intensification, such as the removal of hedgerows to make larger fields, clearance of woody vegetation or woodlands, and removal of features such as relict river channels and pools, all tend to reduce surface storage of flood waters.

In major flood events, where prolonged periods of heavy rainfall precede flooding, soils will be already saturated and the flood alleviation benefits of land management measures are lost. However these measures can attenuate smaller flood events at a local scale when carefully targeted within catchments.

A report commissioned by the Environment Agency in the UK[xvi] concludes that "*There is a significant theoretical basis underpinning relationships between land use and flood risk management but little monitoring data to demonstrate effects. Effects at a large catchment scale are difficult to determine since they are the result of aggregating many local-scale effects which are themselves hard to quantify, and are also dependent on individual physical catchment characteristics. This does not, however, necessarily mean that there is no catchment-scale effect: rather that the nature of the effects differ between different catchments and within each catchment, making them very difficult to detect.*"

There is a strong case to be made for utilising Agri-environment funds for flood management, for specific targeting of agricultural subsidies toward implementing flood management measures on agricultural land.In the UK, agriculture has been estimated to account for 14% of flooding, which in turn results in annual flood management costs of £464 million and damage costs of £1.09 billion in England and Wales[xvii].

Opening up land to flooding

The UK Pitt review was conducted in response to the 2007 severe floods in the UK. One of the recommendations of the Pitt Review is '*One flood defence measure which has proved to be increasingly successful is use of natural processes such as using farmland to hold water and creating washlands and wetlands. Keeping water away from urban areas and slowing its progress to minimise runoff proved successful in the summer. Natural processes are even more effective for smaller scale events*.'

Allowing certain lands to flood, especially in floodplains, is a particularly effective measure to contain floodwaters and lower flood peak downstream. In the UK, the Environmental Stewardship scheme under the CAP has a grassland inundation option, which provides payments to farmers who accept additional flooding on their lands. Payments are made, where river banks are set back or breached to allow more natural flooding regimes. The Environmental Stewardship scheme also includes a range of other wetland habitat creation options (for example, wet grassland, reed bed and swamp habitats) that can assist in flood risk management.

Working with landowners and farmers to facilitate opening up land to flooding with appropriate compensation will be necessary. The UK's 'Farming Floodplains for the Future' initiative provides a useful model by examining new incentives tailored to the delivery of flood management objectives through land use change.

The success of land management measures requires targeting to specific land where hydrological modelling shows that flood attenuation will be achieved. International experience has shown the importance of agri-environmental schemes to allow for NFM and successful catchment based flood management solutions. OPW and DAFM need to develop options for this in a post 2020 CAP.

Some catchments are more sensitive to land use management change and thus will be more appropriate to land use management measures, pointing again to the importance of hydrological modelling and assessment of soils, topography and existing land use in guiding the implementation of measures. It is important to recognise that potential flood risk benefits are only one component of a whole package of multiple environmental benefits that can be delivered through land use management changes[xviii]

Recommendations

The relationship between agricultural land use and flooding in different hydrological settings needs **research** specific to Ireland. Funding of hydrological research to better understand the complex relationship should be made available by the CFRAMS process jointly with the Department of Agriculture, Food, and Marine (DAFM) so that future flood attenuation measures on agricultural land can be appropriately targeted and implemented.

The measures described above can only be delivered through the use of incentives to landowners. A new Common Agricultural Policy is due in 2020 and work is underway now to review the objectives and operation of this policy. There are many ways in which the Common Agriculture Policy (CAP) should facilitate management of floodplain wetlands and other catchment features to attenuate flooding, as part of the payment system to support farmers to deliver public goods. **Rural Development Programme (RDP) payments** (potentially combined with other flood specific funding) are utilised elsewhere from NFM and this needs to be facilitated in Ireland. In particular, (1) restoring the natural hydrological connectivity between river and floodplain so allowing land to inundate more frequently; and, (2) retaining or restoring 'rough' floodplain surfaces, in the form of walls, hedges, coarse and woody vegetation, relict channels and depressions[xix].

Development in floodplains & Floodplain Rehabilitation

Protecting floodplains from development

Natural floodplain wetlands become inundated with water during periods of heavy rainfall. The capacity of a floodplain to store food waters is determined by physical characteristics of the floodplain and the land use, for example a floodplain where water is prevented from spilling out on to the floodplain will not hold back floodwaters from towns downstream. Embankments built along a river sever the connection between the river and the floodplain in all but extreme events.

Where portions of a natural floodplain have been infilled and developed, for example for retail units, industrial estates, and apartments, as has happened across Ireland during the boom, the capacity of that floodplain to store floodwater is lost and downstream flooding exacerbated. Protecting and restoring floodplains to perform their natural flood alleviation function is a crucial action to manage flood risk in Ireland.

Flood risk to housing in urban, suburban and rural areas is increasing as climate change impacts intensify, and it is imperative that we do not add to the problem by continuing to permit housing and other developments in flood risk areas. Managing floodplains is a particularly cost-effective flood attenuation measure. Currently there is a discrepancy between the levels of development permitted in flood risk areas by different local authorities. Anecdotal evidence suggests that some local authorities are still directing development to be located in flood plains, this is a practice that may be widespread.

Recommendations

A **research** project to monitor local authority planning decisions in flood plains would enable better understanding of current practice and then assist improvements in decision making with respect to development and flooding.

All **County Development Plans** and zoning must incorporate strict protection for floodplains from any new development that reduces capacity for natural flooding

An urgent update to the '**Guidelines** on the Planning System and Flood Risk Management (DECLG/OPW, 2009)' is needed, to reflect better understanding of floodplain development, management and rehabilitation.

Training must be provided for Local Authorities to support good practice. Specific supports for councillors, planners, and engineers is needed to address the current poor understanding of floodplain management with respect of development and flooding.

Restoring river channels and floodplains

Most rivers have been straightened, confined with embankments and dredged, a process that contains the river and makes more land available for productive farming. This severs the connection between the river and the floodplain, recuing natural flood storage and increasing the volume and speed of water moving downstream. Major projects around the world have reinstated meanders and lowered or breached embankments in strategic locations in order to slow the flow of water and allow floodwater storage in the floodplain. 'Rehabilitating' the river and its floodplain also involves the creation of ponds and wetlands in the floodplain, reinstating wetland or woodland ecosystems, or creating floodwater storage bunds. The restoration and creation of habitats such as flood meadows and reed beds can act as important stores for flood water and can help to encourage reconnection of rivers with their floodplains, as well as having significant benefits to wildlife and water quality. The overall objective of these projects is to restore the natural function of the river and its flood storage capacity.

Large water storage areas in floodplains, often called 'washlands' are particularly effective for flood attenuation, as they are engineered to store excess water and reduce flood peak. These storage areas may help farmers adapt to increased levels of flooding while continuing to provide them with a source of income.[xx] Because floodplains often contain fertile agricultural land, and are privately owned and farmed, specific supports will be essential to encourage and maximise the use of floodplains for flood attenuation.

Recommendation

Allocate funding for 3 **sub- catchment pilot schemes** implementing NFM with adequate resources for bringing in external expertise, involving local communities, and utilising detailed hydrological modelling and monitoring.

Managed Coastal Realignment with Saltmarsh Restoration

Coastal flooding occurs when storm surges, high waves and high tides and landward flooding resulting from rivers spilling over banks onto estuarine floodplains. Rising sea levels in the near future will greatly exacerbate the risk of coastal flooding. In addition, climate change will most likely cause a more frequent and intense storm surges. Most of our major towns and cities occur along the coast and thus are vulnerable to flooding from sea level rise. Engineered coastal protection works are already in place in most areas vulnerable to coastal flooding or erosion, especially to protect valuable reclaimed land, ports and harbours and vulnerable towns and cities. However with climate change increasing the risks of coastal flooding, the protection offered by existing structures will be tested.

Natural buffers such as **coastal wetlands** can play an important role in attenuating seaward flooding. Salt marshes, found in sheltered areas of the intertidal zone, dissipate wave energy and provide defence against tides and waves, particularly during stormy conditions. They also have a large storage capacity for high river levels or high tidal levels. This will be of most benefit in narrow inlets, bays and natural harbours, such that the tidal flow cannot be displaced along the coast. Even a small width of fronting saltmarsh can significantly reduce the height of sea walls required to achieve the same level of protection and thus initial construction costs[xxi]

Managed realignment is where breaches are made in existing coastal defences to encourage regeneration of habitats such as saltmarsh and create a new line of setback defence. Managed realignment is appropriate where historical land reclamation has cut off a coastal habitat from inundation and thus converted former coastal wetlands in to land for farming or industrial development.

Co-benefits of managed coastal realignment

Sea-level rise will reduce the area of intertidal habitats through a process called 'coastal squeeze' unless these wetlands are allowed to migrate landward. The loss of saltmarsh and mudflat as sea level rises will result in the loss of habitat for the thousands of non-breeding migratory waterbirds which spend the winter in Ireland each year. Many coastal habitats including estuarine wetlands in Ireland are designated as Special Protection Areas under the European Birds Directive because of their importance for wintering waterbirds, and as Ramsar sites under the Convention on Wetlands. Accordingly, Ireland must act now to mitigate against future losses of threatened species and habitats. For some sites, managed realignment will be essential, not only for the benefit of birds and biodiversity, but also to minimise economic loss.

Across the UK, flood alleviation measures have included creation of new saltmarsh habitats in dozens of locations through managed realignment, and have demonstrated success for both biodiversity and flood alleviation. In Ireland, one pioneering project to trial this approach is being carried out by Fingal County Council in the Rogerstown Estuary, where an embankment has been levelled to allow very high tides to flood on to several acres of level grassland which will see the lands eventually reverting to saltmarsh.

Recommendations

As an immediate measure, **guidance** is needed for development consent agencies, including national and Local Authorities, on how SEA and other environmental assessments can be conducted to account for 'coastal squeeze'. This is to prevent development in locations likely to be required for coastal NFM in the future.

Pilot schemes should be facilitated for managed realignment and saltmarsh restoration in several locations around Ireland.

In Scotland, **payments** are available for breaching, lowering or removal of coastal embankment as a managed realignment measure in target areas, covered by the Scottish Rural Development Programme. To implement coastal realignment here, Ireland's RDP should also include such measures.

Sustainable Urban Drainage Systems (SUDS)

Urban areas are characterised by having roads, roofs, carparks and pavements - all impermeable surfaces that prevent rainwater soaking into the ground. In Ireland the increase in impermeable paving in urban areas has been significant, with the area of artificial surfaces increasing by approximately 15% since 2000[xxii]. Sustainable Urban Drainage Systems (SUDS) refers to various measures that deal with urban run-off water, such as permeable paving in public spaces, creating ponds or wetlands within the urban environment to store storm water.

Recommendation

SUDS should be included in new planning framework due in 2017.

4. Overarching Recommendations

The Floods Directive requires a catchment approach to flood management to be taken by all EU member states. As part of this process, a national Catchment-based Flood Risk Assessment and Management (CFRAM) programme is run by the OPW which assesses the risk of flooding in coastal and inland areas and considers options for flood alleviation. The CFRAM process is tasked to prepare a series of flood risk management plans that set out the policies, strategies, measures and actions that should be pursued to manage flood risk. The CFRAM programme is expected to consider NFM (referred to 'land use management and natural water retention measures') however draft plans released for public consultation during 2016 did not incorporate NFM measures to any significant extent.

Develop a working group on Natural Flood Management

In addition to the specific recommendations contained in this submission, Friends of the Earth recommends that a specific national working group for Natural Flood Management be established under the CFRAMS process to advise the further development of all FRMPs.

The working group should be charged with investigating NFM approaches for Ireland and would need to involve the OPW, DAFM, the Forest Service, the EPA, the Department of Communications, Climate action and Environment, the NPWS, Local Authorities, and environmental NGOs. Structures for the participation of experts and interested parties should be factored in to the structure of the working group. The working group could bring in expertise from the UK, where many pilot schemes have been running for several years and where understanding of NFM is more advanced than in Ireland. The working groups would be charged with implementation the recommendations laid out in this report, including funding pilot projects and producing guidance for use within this CFRAMs planning cycle.

Communications

Adopting NFM will require public support and buy-in from landowners. A shift from hard engineered flood protection toward catchment based NFM measures to reduce flood risk will require a significant programme of public engagement from the outset. Implementation of measures will be challenged by political pressures applied at all levels from national organisations to local pressure groups, unless there is a well-resourced public engagement programme to involve sectoral interests in the assessment of NFM and how best to implement measures, especially those which will involve incentivised land use management such as payments for woodland creation and for allowing certain lands to flood as part of a catchment based approach.

Pilot Projects

Funding should be made available in Ireland for several trial projects to investigate how natural flood management catchment scale approaches might reduce flood risk. Ideally these trials should be led as a joint approach by the community and academics, so as to strengthen the demonstration value of each pilot project. The involvement of relevant agencies will also be necessary, including the

Department of Communications, Climate Action and Environment, the OPW, the Forest Service, NPWS, and the relevant Local Authorities.

Wetland protection

Halting further loss of wetlands can be effectively achieved through a cessation of wetland and floodplain reclamation associated with agriculture, forestry, port expansion, construction, and other land use changes. The precautionary principle must be applied to the protection of all wetlands that potentially play a significant role in flood attenuation and simultaneously provides funding for research to improve hydrological understanding of the extent to which various wetlands perform this role.

5. Case Studies on Natural Flood Management

'Slowing the Flow' Project at Pickering, North Yorkshire

The communities of Pickering and Sinnington in North Yorkshire are prone to flooding, with frequent events since 1999. In 2008/9 a partnership made up of Defra agencies, local authorities, academics and the local community successfully applied for funding for a demonstration project to look at how changes in land use and land management could help to reduce flood risk, as well as provide other benefits. The 'Slowing the Flow' project subsequently undertook catchment scale modelling to target the implementation of a wide range of measures to reduce, slow and store flood water in the landscape and reduce the scale of flood generation downstream.

Following detailed hydrological modelling, targeted measures have been implemented in the right locations along those tributaries and areas within each of the catchments that offer optimal benefit for flood attenuation. To date, over the 6 years since the project has been running, the following measures have been implemented:

- No-burn buffer zones established along all moorland watercourses and 3.2 ha of bare ground re-seeded with heather to increase soil infiltration and reduce flood generation.
- 29 ha of riparian woodland plus 15 ha of farm woodland planted to reduce and slow flood flows.
- Forest plans revised to help secure opportunities for forest re-design and management to reduce flood run-off, including restoring 5.9 ha of riparian woodland buffers
- Roof, yard and soil works undertaken on 10 farms to reduce site run-off and diffuse pollution, as part of Catchment Sensitive Farming.
- 187 heather bale check dams constructed within moorland drains and gullies to slow run-off and reduce erosion.
- 167 large woody debris dams constructed within streams and rivers to re-wet the floodplain and hold more water in the upper catchment.
- A trial of two novel larger 'timber bunds' as a potentially low-cost and low-impact method of retaining and temporarily storing flood waters
- A large flood storage reservoir constructed to store approximately 120,000m3 of flood water.

- A network of water level recorders installed to monitor the effects of the land management changes on flood flows.

Observational evidence and assessments of rainfall and flows during recent events have indicated that the delivered measures are working as expected, with detailed hydraulic modelling showing that they will reduce the probability of flooding in Pickering from a previous 25% chance in any one year, to a 4% chance or less. The recently completed large flood storage reservoir alone is designed to deliver this standard of protection, with the other interventions acting to further reduce the flood risk.

On Boxing Day 2015 the flood storage area was tested for the first time in response to Storm Eva, and worked as it was designed to. Analysis of river levels and historic data suggests that measures reduced peak flows by around 20% compared with records of similar rainfall events in recent years, more than half of which may be attributable to the upstream measures.

'Slowing the Flow' is one of three Defra sponsored projects looking at how changes in land use and land management can help to reduce flood risk, as well as provide other benefits such as improved water quality, enhanced biodiversity and carbon sequestration. The partnership project is led by Forest Research and involves the Environment Agency, Natural England, Forestry Commission England, the North York Moors National Park Authority, Durham University, Local Authorities, and the local community. The project has clearly demonstrated how a strong partnership approach can succeed in delivering an integrated set of land management measures to reduce flood risk at the catchment scale, as well as provide wider multiple benefits for local communities. To build on the project's success the Partnership is working with others to explore how similar approaches might be scaled up substantially across the Derwent catchment as a whole.

'Room for the River' in The Netherlands

The Dutch have a long history of land reclamation and flood protection through engineered flood defences. However severe flooding occurred in 1993 and 1995 when several large rivers swelled to unprecedented heights and huge tracts of farmland were inundated. 250,000 people and one million head of livestock had to be evacuated during the 1995 when the dykes almost failed. In expectation that climate change will result in increasing flood risk, the Dutch embarked on a national adaptation programme to allow for the threats and uncertainties of increased future flooding.

The resulting 'Room for the River' programme has been moving banks and restructuring flood defences on the four major rivers, restoring the natural floodplain in places where it is least harmful in order to protect areas which need to be defended most from flooding. Instead of raising the level of the dykes, dykes have been relocated to open up floodplains. Marshes and flood water storage areas have been created to temporarily store flood waters when needed. Floodplains levels have been lowered to allow for greater flood water storage. Homes and families have been relocated to allow for expanded floodplains. The Dutch case shows that adapting to higher flood risk requires a change in approach to spatial planning and changes in many different aspects of policy making.

Prevent flooding by restoring ecosystems in the Dijlevallei, Belgium

A project in the valley of the river Dijle south of Leuven in Belgium reconnected the floodplain to the river so as to increase water retention upstream and prevent flooding in the town of Leuven, which prior to the project had been subject to regular flooding. In this LIFE funded project, Natuurpunt, a Flemish NGO, purchased land in the floodplain upstream of the town which had been subject to agricultural intensification and plantation forestry. As part of the project, 109 ha of land in the flood plain came under conservation control and several large 'depression' areas came under management for water retention for flood alleviation. In total, 208 ha, or 42% of the project area, is owned by the NGO and the land management agreements with other landowners extend the reach of the project. Land in the floodplain was restored to grassland, swamps and ponds and ash-alder woods. Alluvial woodlands have been restored which now flood in winter. Reed beds have been created which store flood water and provide wildlife habitat. Maize crops have been replaced with extensively managed grassland and hay meadows to restore the lands for protected species. Drains have been blocked so that flood waters are retained in the floodplain. Recurring management is done by local farmers.

For more information on this project, see http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=299

The restoration of Sinderland Brook, England

An example of a successful River restoration project as art of a new development is the Stamford Brook development and the restoration of Sinderland Brook. Sinderland Brook was canalised in the 1970s by the local water authority. In the late 1990s a proposal to restore the brook and its floodplain was prepared by the National Trust, the implementation of which became a condition of the Development Agreement between the developers (Redrow Homes and Taylor Wimpey) and the Trust. The aim of the project was to transform the canalised watercourse, which was previously restricted to a floodplain offering only limited protection to the development site and established residential properties to the north, to a dynamic meandering river allowed to adjust within its own semi-natural floodplain.

This project has turned a previously canalised and straightened brook back into a meandering stream with its natural floodplain. At 1.8 km, this is the largest river restoration project in England. The initial 1.3 km of the restoration scheme was funded by the National Trust and the developers, with the Environment Agency contributing to the final phase of around 500 metres.

The development also includes a sustainable urban drainage system (SUDS). Surface water run-off from roofs, parking courts and driveways is piped into a series of temporary ponds (swales) that run through the development through wildlife corridors. The water can be stored safely in the ponds, which allow the water either to percolate back into the ground or discharge into the restored Sinderland Brook river corridor. The SUDS system has been designed to store a 1 in 100 annual chance of occurring flood event.

A key feature of the Sinderland Brook restoration is a restored and dynamic river environment, which contributes notably to local environmental quality and which significantly enhances flood protection for the site and an established residential community to the north. Not only has the level of flood risk been reduced from 1:35 years to 1:300 years, the Sinderland Brook restoration rationalised the flood envelope such that the developers could actually build more houses on the site. Landscaping and the river restoration also improved the amenity of the local area.

Corkagh Park, Dublin

Corkagh Park in Clondalkin, County Dublin, is thought to derive its name from the Irish 'Corcach' meaning marsh. The River Camac flows through the middle of the park and the area was once part of the flood plain of the river. The Camac is Dublin's fourth largest river and has a catchment area of 6,637 hectares. Flood risk is calculated at once in every 28 years.

The most recent flooding incident was in June 1993 when the river overflowed its banks at the south eastern section of the park causing damage to nearby houses. Since then, elements of the River Camac Improvement Scheme were devised to help alleviate flood risk. Sections of parkland were lowered by the removal of almost 60,000 cubic metres of soil and the formation of constructed wetlands (large stromwater retention ponds). Five off-line lakes, controlled by weirs, were constructed on the floodplain. The resulting lowered areas serve as a holding area to retain flood waters and allow them to be slowly released back into the river as the flood subsides.

A combined area of 3.54 hectares is covered by the wetlands and they have a maximum water depth of 1.2m. A permanent wetland can accommodate a further 0.5m water level increase, which was estimated to yield a 13,500 m3 storage capacity, equating to 25% of total emergency capacity required. When not in use, the remaining flood attenuation ponds act as wetland meadows for wildlife. Upstream floodgates are operated manually, with managed outflows controlled by pressure release which slowly discharges floodwaters. One of the ponds is maintained with a permanent water level to facilitate a 'put and take' fishery that was designed into the project as an amenity.

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