



Elaborated business case Eddleston Water

Deliverable of Work Package 5 - Upscaling

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Photo by C. Spray.

Colophon

Building with Nature – Elaborated business case Eddleston Water

Deliverable of Work Package 5 – Upscaling

Part of the INTERREG Building with Nature project

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Authors

University of Dundee – Prof. Christopher Spray

Royal HaskoningDHV – Jasper Fiselier

Royal HaskoningDHV – Simeon Moons

WP5 Project Leader

EcoShape – Erik van Eekelen

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Summary

The potential of Natural Flood Management (NFM)

The Eddleston Water project is Scottish Government's long-running study into the effectiveness of using natural flood management (NFM) measures on flood risk reduction and riparian ecology, and their wider costs and benefits. As part of this pilot, a large number of different NFM measures have been implemented across the 69km² catchment area of Eddleston Water, a tributary of the River Tweed in Scotland. The main focus of work has been on flood risk reduction and habitat improvement. The measures include woodland planting, placing large woody structures in-stream, wetland creation, re-meandering and flood bank removal. The project started in 2010 and the effects of NFM measures have been monitored since 2012. In 2020 a hydrological catchment model was developed to assess the effects of different combinations of NFM measures under varying flood conditions, and to identify locations best suited for NFM measures.

The observations thus far include an increase in lag time before reaching a flood peak and an increase in infiltration in mature deciduous woodlands compared to adjacent pastures and conifer woodlands. Some effects of NFM measures, especially of replanting, will take time to become fully effective, and the full benefits may only show when trees and forests have matured and soil ecology and structure have been fully restored. Initial results confirm and extend to a larger catchment scale than those reported elsewhere, with the conclusion that NFM may substantially reduce peak discharges in small catchments below 20km², and for frequent floods, but that this reduction is less evident at a larger scale and when it comes to major floods that occur more rarely.

The ecological effects of NFM are more certain, with proof that re-meandering previously straightened sections of water course restored in-stream features and morphology, contributing to the provision of more diverse and better habitats for fish and other aquatic organisms, as well as significantly increasing the length of water course.

The wider ecosystem service benefits of NFM

NFM measures provide many ecosystem service benefits beyond just flood risk reduction. Those relating to carbon sequestration, water quality, biodiversity, timber production and angling are potentially of great importance. Of these benefits, those of carbon sequestration are probably the largest, and whilst the beneficial effects of NFM measures on flood risks have not yet been included in detailed calculations, they may be limited compared to the overall wider ecosystem service benefits.

In an initial assessment, ecosystem service benefits were estimated using a benefit transfer methodology, based on figures obtained from other studies. Ongoing work focuses on calculating the detailed costs of implementing NFM, alongside the agriculture income foregone. The Eddleston project will use the BEST tool to assess the environmental, social and economic benefits of using NFM measures (alongside traditional, structural defences). Results are expected at the end of 2020.

Finally, the project is developing recommendations as to how best to integrate NFM measures and options into the formal Options Appraisal and evaluation processes for a Flood Management Scheme assessment locally and nationally.

The business case of NFM

The business case for NFM needs to be based not just on its benefits in terms of flood risk reduction or the improvement of ecological status, although both represent important objectives and venues for financing NFM, but also on the wider ecosystem service benefits related to NFM. The potential effects of NFM on flood risk reduction in the case of a 1 in 200 storm event is limited. In developing a NFM based flood protection strategy, one needs to consider hybrid combinations with conventional flood protection structures, property flood resilience and flood insurance – as part of a total package of Sustainable Flood Risk Management. Other

existing sources for funding such as those relating to afforestation and carbon storage, both important policy goals in Scotland, also need to be considered.

The wider framework for setting a business case for NFM is ideally therefore set within the context of an integrated catchment plan. Flood Risk Management in Scotland which includes NFM, should be planned at a catchment scale and should encompass other relevant ecosystem service benefits, recognising how these may contribute to local communities and support the business model of individual farms and landowners. This framework is much more comprehensive than a traditional formal flood protection scheme study which has a much more narrow focus.

The implementation of NFM measures requires the cooperation of landowners and farmers. They are generally willing to consider participation when the implementation of NFM does not lead to additional costs, or when these costs are fully compensated. They prefer to remain in control of their land and they prefer a long-term guaranteed income stream, as may be generated by certain NFM measures, as opposed to one-off capital payments. Subsidy payments for the provision of 'flood risk reduction' ecosystem services are seen as an increasingly important tool in this respect.

A comprehensive planning process based on the voluntary participation of stakeholders that aims to enhance the livelihoods of local communities requires a coordinating organization that knows the area and its stakeholders, and holds their trust (such as Tweed Forum). Building such an organization takes time, and hence building a business case, or even building with nature, starts with building with people a network before designing and assessing potential measures.

Introduction

Objective of this business case

The Eddleston business case is one of three different business cases within the work package 5 of the EU INTERREG North Sea Region Building with Nature programme; each with a different focus and lessons learned. The Eddleston business case differs from the others in that primarily it was set up as a research platform. It focusses on the potential of natural flood management (NFM) measures; the involvement of stakeholders; and how a business case can be set up, so that it supports design and decision making in the case of implementing NFM measures on a catchment scale. The Eddleston Water project is Scottish Government's long-running study into the use and effects of NFM on flood risk reduction and riparian ecology, and their wider costs and economic benefits. The project was initiated and is managed by Tweed Forum, with support from the Scottish Government and Scottish Environment Protection Agency (SEPA), and the University of Dundee.

The Eddleston case is an ongoing study in NFM, with the focus on flood risk reduction and ecological restoration. The aim is not only to study the impact of NFM measures on the reduction of flood levels and ecology, but ultimately to reduce the risk of floods in the communities of Eddleston and Peebles, whilst also contributing to the aim of achieving Good Ecological Status according to the EU Water Framework Directive (WFD). Regarding the risk of flooding, SEPA's flood risk assessment shows some 1079 properties at risk of flooding in Eddleston (53) and Peebles (1026) under a 1:200 year return period scenario (*pers. com.* SEPA, August 2020). The project started with a Scoping Study in 2010, followed by the installation of a detailed hydrological and ecological monitoring network to collect baseline data before the implementation of any NFM measures. The first NFM measures were introduced in 2012 and the study has gained much knowledge regarding the effects of NFM measures, the most effective way to approach stakeholders, and what motivates them to participate on a voluntary basis.

SEPA published a handbook for NFM (<https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf>) which gives a comprehensive overview, as well as detailed information needed for identifying, designing and financing NFM. Tweed Forum produced a series of guidelines directed at farmers for implementing NFM (<https://tweedforum.org/our-work/publications/>), as well as other material that describes the Eddleston catchment area and addresses relevant technical and also financial issues (<https://tweedforum.org/our-work/projects/the-eddleston-water-project/>). Eddleston is one of the most advanced studies on the application of NFM in the UK, for the purpose of flood management and reaching ecological WFD objectives and, crucially the only one based primarily on empirical evidence that is being delivered at a large catchment scale (others in UK are <20km² and most <10km²).

Approach

EcoShape and the Eddleston case have been in contact throughout the EU INTERREG Building with Nature programme on all relevant issues related to the business case. Work at Eddleston on valuing the multiple benefits of NFM measures (ecosystem services) and on integrating such environmental, social and economic assessments into a standard Flood Scheme assessment and cost-benefit analysis is ongoing. Flood modelling work, just completed by JBA Consulting (2020b), has given some early results on hydrological issues. In addition, initial investigations working with JBA has given some indicative results on economic analyses of ecosystem services, but these are incomplete and, at this stage must be treated with caution. A full assessment of the costs and benefits of NFM measures across Eddleston is now being developed by the project team using the BEST methodology (working with Mott MacDonald consultants). In the meantime, this report focusses on lessons learned so far.

Outline of this case study

The report describes the following:

- Case description, characteristics of the catchment areas and the NFM that have been tested.

- Stakeholder involvement, noting that Eddleston is based on voluntary participation by landowners and farmers. The role of the Tweed Forum was vital in informing and negotiating with farmers.
- The potential of NFM, with special reference to measures and results from the Eddleston project.
- Ecosystem services benefits of NFM as observed and assessed in the Eddleston project.
- Lessons learned for setting up a business case.

Case description

Location

The project is located in Scotland, UK. The Eddleston Water is a tributary of the River Tweed in the Scottish Borders, with a catchment of 69km² draining south to join the main river at Peebles (see Figure 1). It is a typical small Scottish rural catchment, with a mix of forestry, rough grazing and improved grassland. Within the catchment NFM measures have been taken at various locations (see Figure 1).

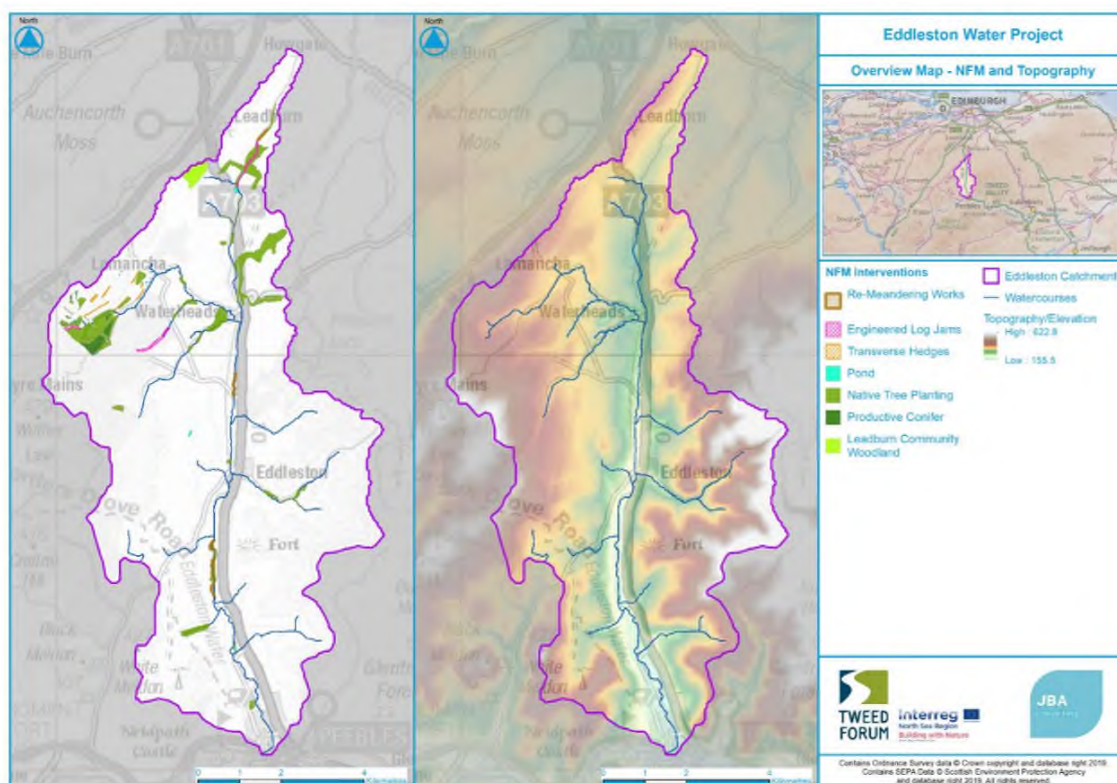


Figure 1. Overview map of the Eddleston catchment area with NFM measures (left) and topography (right). Figure obtained from JBA Consulting (2020a).

Scope and project objectives

The Eddleston case is a long-running research study into the effects of NFM measures. Measures have been implemented and their effects on hydrology and ecology have been monitored for many years now. At the time of writing, a comprehensive combined hydraulic-hydrological catchment model has just been built and is being tested. This will enable an assessment of various NFM deployment scenarios and their impact on flood risk, as well as on other ecosystem benefits. As a research study, the Eddleston project is at a stage that it can assess the potential of NFM in its own catchment area; make comparisons between NFM scenarios and conventional flood protection schemes; and it is generating essential information that would be needed for a comprehensive business case, that addresses all related ecosystem services. The implementation of the pilot has also generated important lessons on how to approach and convince farmers and landowners to participate in the implementation of NFM.

The pilot project has three main objectives:

1. To investigate the potential to reduce the risk of flooding to downstream communities through the utilisation of NFM measures;

2. To improve habitats for wildlife and fish, and raise the ecological status (EC WFD) and condition of the river; and
3. To work with landowners and farmers in the local community to maximize the benefits of the work, whilst sustaining farming livelihoods and practices.

Current phase of the pilot

The project, which began before engagement within the EU INTERREG Building with Nature programme, has had several phases so far:

- 1) 2009/10: Scoping study – led by Dundee University, with Cbec Ltd, this produced a detailed characterisation of the river and its catchment. It identified a wide range of potential NFM and habitat restoration measures across the whole catchment that theoretically might be worth implementing; developed a comprehensive Monitoring Strategy; and developed a Stakeholder Engagement Strategy.
- 2) 2011: Installation of the baseline hydrological and ecological monitoring network and identification of the initial potential sites and willing landowners for the implementation of NFM.
- 3) 2012 onwards: Implementation and monitoring of the NFM and associated habitat improvement measures.
- 4) 2019 onward: Development of a comprehensive combined hydraulic-hydrological catchment model (by JBA Consulting) with which the effects of different NFM combinations and climate change/flood risk scenarios can be assessed,
- 5) 2020: initial report on potential ecosystem benefits (JBA consulting), followed by the ongoing development of a more comprehensive environmental, social and economic cost-benefit assessment of the implementation of NFM measures across the catchment (by Mott McDonald). This is using the best available assessment methodology for multiple benefits and developing the means to integrate into standard local and national Flood Scheme Options Appraisal.

The current phase can be described as a mature study ready for upscaling.

Physical system

The Eddleston Water has a catchment of 69km² with a topography as shown in Figure 1. It is a typical small Scottish rural catchment, with hills on either side and a mix of forestry, rough grazing and improved grassland. The most wide-spread habitats in the catchment are improved grassland (40%) and coniferous plantations (13%). These have both increased significantly since 1946 (from 20% and 1.4% respectively), at the of costs semi-natural habitats such as bogs (Ncube *et al.* 2018). The straightening and embankment of the Eddleston headwater has led to a decrease in habitat quality and quantity for fish and other aquatic organisms.

Mean annual rainfall on the high ground either side of the valley exceeds 1500 mm, declining to less than 850 mm in the valley. Whilst ultimately the choice and location of NFM measures that have been tested relies on the agreement of the relevant landowner/farmer on whose land they could be developed, their positioning is adapted to the landscape and the characteristics of the river and river valley. In spite of its limited size, the differences in rainfall between the valley and upper parts are large, with most of the rain falling in the headwaters. Due to its limited size, rainfall is followed within several hours by larger discharge events in the town of Eddleston and Peebles. Therefore, the way in which some types of NFM measures, such as log dams and ponds, could delay peak flow, is an important aspect of the work, since this could greatly improve early warning to downstream communities.

Societal system

The primary land use in Eddleston is sheep farming, both intensive and extensive, and landowners and farmers are the most important stakeholders when it comes to the implementation of measures. All NFM measures are designed and implemented on a voluntary basis. Citizens in Peebles and Eddleston are the main beneficiaries of flood protection measures.

Flood risks Eddleston catchment area

High peak discharges on the Eddleston mainly lead to flood risks in the downstream town of Peebles (Figure 2). Smaller storms lead to limited damages, and flood damages increase beyond annual probability of 0.033, or a storm with a recurrence interval of once every 30 years to sharply increase in the case of storms with a recurrence interval less than once every 100 years (see Figure 3).

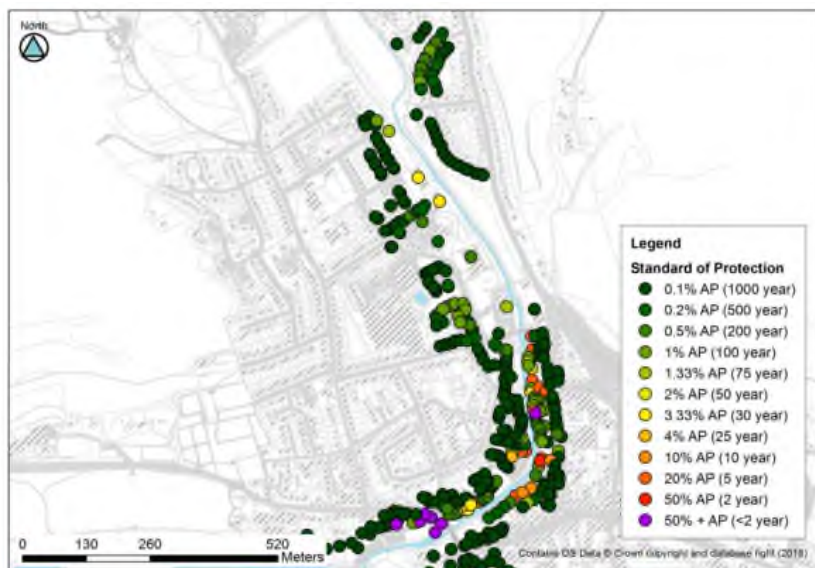


Figure 2. Standard of protection in a Do minimum scenario for properties in the town of Peebles. Figure obtained from JBA et al. (2019).

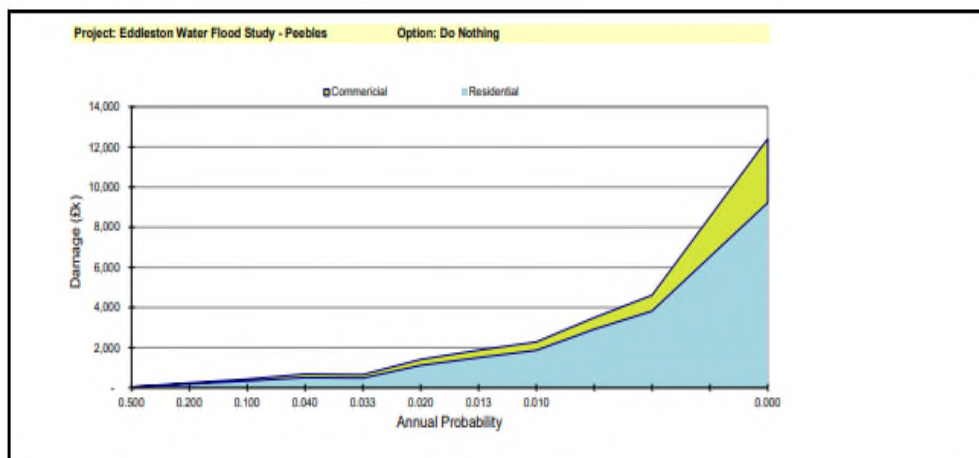


Figure 3. The expected flood damage for the Eddleston catchment area -Peebles against annual probability. Figure obtained from JBA et al. (2019).

Institutional system

Several organizations are involved in the Eddleston project as well as in the management of the catchment area. The Tweed Forum is one of the most important and coordinates the project. Tweed Forum was established in 1991 with the aim to further the sustainable use of the Tweed catchment, of which the Eddleston is a tributary. Work is done on project and strategic level. Tweed Forum has many organisations as members, all of which have an interest in the management of the Tweed and its environment, including Non-

Governmental Organisations (NGO), local government, communities, local stakeholder groups and the private sector.

In 2019 a revised and updated policy document was published by the Scottish Government (Scottish Government 2019) (<https://www.gov.scot/publications/flood-risk-management-scotland-act-2009-delivering-sustainable-flood-risk-management/>) that strongly advocates an integrated catchment approach to flood risk management, with due attention to the potential of natural flood measures and with an important role for local stakeholders. It emphasizes the need to consider not only traditional forms of flood protection, but also flood resilience and flood insurance, as well as the use of NFM. It also highlights the role of land use planning as an important tool to prevent an increase in flood risks, by avoiding urban developments in flood prone areas. It stresses the need for structural and sustainable long-term solutions that are adaptable and take into account climate change. Acknowledging that the rural economy is of vital importance to local communities as well as to the national economy, it advises that the measures needed for flood risk management should be balanced with what is needed for a vital rural economy and the protection of cultural heritage and the natural environment.

Stakeholder process

There are many different types of NFM which can be implemented in different locations. A major challenge and potential constraint is the willingness of individual farmers to implement proposed measures on their land. The direct involvement of farmers and other such stakeholders is thus key to setting up and sustaining the Eddleston pilot, and for the next step to be taken. Important stakeholders are the farmers/landowners in the area, as well as the key environmental regulators, planners, co-financing institutions and potential funding bodies.

The process of stakeholder engagement was informed by a Stakeholder Engagement Strategy, with different types of stakeholders being approached and communicated with (two way) using different means and frequencies of contact. The most important stakeholders were engaged through one on one meetings and discussions, whilst others were engaged through public meetings, newsletters and other media channels. The stakeholder process was conducted by Tweed Forum, which is a long-established and well-respected non-governmental participative catchment organisation. As such it operates as a 'Trusted Intermediary' working with farmers to explore opportunities for the implementation of NFM measures. Awareness building is an important element, but also sharing information with farmers that shows the consequences of measures to individual farmers, and being clear as to the financial implications at all times.

Financing NFM measures in the Eddleston catchment

Funds for the Eddleston study have come from many different sources, with the Scottish Government, SEPA (through its Water Environment Fund) and, during this phase the EU North Sea Region INTERREG being key. Other sources have included: Forestry Grant Scheme, Scottish Rural Development Program, carbon capture funds, Woodland Trust, Scottish Power, Cemex, Borders Tree Planting Grant, Sustrans, Forest Carbon, Forest Research, Environment Agency (England & Wales) and, most importantly farmer in-kind contributions.

The Scottish Rural Development Program (SRDP) features several funds that can potentially be used for financing NFM, such as the Agri-environment Climate Scheme and the Forestry Grant Scheme. Some funds are very specific, and some come from the private sector such as Carbon Offset Schemes and Biodiversity Offset Schemes. Tweed Forum plays an important role in coordinating and accessing many of these funds. In addition, they often work with farmers to deal with all the technical 'paperwork' and conditions around grant application and use for them.

Several of these funds do not as such support NFM for the purpose of flood risk reduction per se, but target other ecosystem services, such as carbon sequestration, biodiversity, afforestation or protection of heritage. Some only contribute to initial capital works, while others may contribute to post-implementation maintenance. Financing from multiple sources can be complex. This implies that at present promotion of NFM schemes needs to develop a mixed approach to financing that closely matches the support mechanisms and funding streams potentially available for different NFM measures. In particular, the use of a mix of funding sources, including

grants requires detailed knowledge of opportunities, intensive communication and negotiation skills, that are backed up by information on the costs of a scheme to individual farmers. This aspect has been developed further in the form of a Policy Brief from the Building with Nature programme.

Building with Nature in this project

NFM measures have been studied in several pilots in the UK over the years, with Eddleston standing out as being longer than nearly all, at a larger catchment scale than most, and being empirically based (with supporting modelling), such that it is an ideal research platform. NFM encompass different measures that are embedded in a catchment wide approach: from source control in the headwaters (reducing rapid runoff generation); through surface water, groundwater and river channel pathways (reducing conveyance on hillslopes and in river channels); to floodplains and other lowland areas (temporary storage). Within these locations, NFM measures can act through three main mechanisms: - River and floodplain restoration and management; Catchment woodland management; and Landscape storage and run-off management. The measures piloted in Eddleston are (see also <https://www.nfm.scot/case-studies/eddeleston-water-tweed-catchment>):

Woodland planting – 207 ha (over 330,000 native trees) Planting helps increase landscape roughness, slow down overland flow, and increase infiltration. Trees were planted on:

- Headwater/gully - The main focus has been on recruiting areas for riparian planting in the headwater streams where floods are generated.
- Floodplain – A limited area because floodplains are often some of the best land on hill farms so scope for large scale plantings is limited.
- Transverse strips – Transverse hedges, to intercept sheet run off on grazed fields and to encourage infiltration. 2500 m of transverse hedges have been planted to date.

Large woody structures – 116 large high-flow log structures in upper tributary streams – that hold back water in high flows, encouraging spillage onto the floodplain, inducing in-channel sediment deposition (i.e. aggradation) and delaying the flood peak.

Wetland creation – 28 upstream ponds and 1 large floodplain pond. Each pond has an extensive ‘freeboard’, so they take a while to fill up in high rainfall events thus helping to delay and flatten out the flood peak. The 28 ponds already dug are concentrated in the upper catchment and vary in size, but exceed 7,000 m³.

Re-meandering – 2.9 km Re-meandering on five separate sites on the main stem of the Eddleston Water. Whilst the NFM benefits of re-meandering are quickly drowned out in large flood events, increasing channel length and diversity will have a role in reducing channel velocities and slowing the flow. The new courses increase the existing individual lengths of channel by between 8% -46%.

Flood bank removal – 900m removed. Much of the main stem has been embanked over time to reduce inundation on agricultural land and protect the former railway. Where re-meandering works have taken place, the flood banks have been removed from both sides of the channel.

The total cost of physical works amounts to £723k across 20 different landholdings, with the majority of that attributed to fencing and planting. The main funder has been Scottish Government but, as noted Tweed Forum has been successful in securing a very wide range of public and private funding sources. These include SRDP, Water Environment Fund, Woodland Trust, CEMEX, Forest Carbon and Scottish Power. The in-kind contributions of the land managers, land and labour, are also significant.

Stakeholder and voluntary participation

Key findings (source: Spray, C.J., Arthur, S., Bergmann, A., Bell, J., Beever, L. and Blanc, J. (2015), Land management for increased flood resilience, CREW CRW2012/6. Available online at: crew.ac.uk/publications).

This work was undertaken as part of a separate contract for Scottish Government by Prof Spray and colleagues, with the assistance of Tweed Forum. However, all results were drawn from detailed questionnaires distributed within the Tweed catchment and many from farmers in the Eddleston catchment itself. It also included a study on Agricultural Income foregone for NFM by SAC Consulting.

Farmers' attitudes to NFM measures:

Planting trees along a watercourse as an NFM measure is the most likely to be favourably considered, but NFM measures that involve a reduction in yield or useable land area are not favoured. Significant concerns exist over potential loss of capital and annual values due to loss of workable land and, more widely on the loss of control over how land may be used in the future. Financial incentives are more favoured than non-financial incentives and annual payments are more attractive than one off payments. Full cost grants are preferred over partial grants. Farmers require evidence of the effectiveness of measures before committing to a scheme.

Potential impacts of NFM measures on farm income:

The impact of different NFM measures on farm income varies according to the type of measure and its location within the farm system. Financial impacts include loss of agricultural income; loss of agricultural subsidies; retention of other fixed costs and additional management costs, offset by reductions in variable costs and some fixed costs. Impact on subsidy income can be assessed through consideration of impacts of NFM measures on the main agricultural support schemes. Loss of income, and therefore level of income foregone is highest on the best performing land, such that costs of compensation will be greatly reduced by targeting NFM measures on poor land and unproductive farms. Removing land from eligibility for subsidy payment results in a marked rise in compensation required. The relative effect is much greater on poor hill land where subsidies make up a higher proportion of farm income.

Policy instruments to support NFM in Scotland

The use of tax-based incentives to encourage uptake of NFM measures received a mixed response. There was limited support for auction schemes and service trading options. Very little support is shown for outright purchase of land or lease back arrangements, due to loss of control over land. The policy context already offers two potential approaches for encouraging NFM via economic incentives. The Flood Risk Management (Scotland) Act 2009 allows for agreements to be established between local authorities and land managers, which could be one route to promote widespread uptake of NFM measures. Secondly, it may be possible to utilise the Scottish Rural Development Programme to make it better able to accommodate NFM.

Targeting NFM measures on Scottish farms:

Certain NFM measures are more attractive to farmers than others. Those measures generally most favoured are woodland planting in hill and in-bye areas, and the fencing off of water courses. NFM measures deliver for flood risk reduction at different scales and those that are not seen as favourable by farmers may still be very relevant; their introduction requiring other incentives and means through which they can be delivered. A catchment approach must be taken to the planning, approval, design and implementation of NFM measures.

Landowners, their business model and priorities

Many farmers in the Eddleston catchment, and for most of the Scottish hill and mountain areas, engage in sheep and beef cattle production. Stock are grazed on the hills, whilst land close to the farm, usually on flatter topography and with deeper soils is used to grow grass/silage for winter fodder. Grazing land can be extensively used, or intensively with more sheep per hectare and usually also on improved grazing land. This combination

of upland pastures and floodplain silage and grazing is intrinsically linked, and their capacities to support livestock farming is usually well matched.

Farm income is the net sum of costs and benefits. The benefits consist mainly of cattle and sheep sales, but also or foremostly of various forms of subsidies. Without subsidies, most farms across Scotland would have a negative income. There may be a little complementary income out of tourism, timber, game sport, etc.

There are several NFM measures with a minimum impact on the farm economy, like the many measures that can be taken to improve the riverbed. Afforestation has a direct impact, especially if this means that the land can or is no longer used for grazing. Afforestation comes with a shift in subsidies, from farming to forestry. The study by Spray *et al.* (2015) shows that the potential reduction in agricultural income is very different between extensively used pastures in the uplands and the lowlands. The willingness of farmers to implement NFM on their most valuable fields is therefore very limited. A survey of farmers revealed how farmers look upon the implementation of NFM (see Box), along with a detailed analysis of income foregone if adopting NFM measures (with respective loss of subsidies calculated within).

Interviews show that farmers are more willing to consider adopting NFM measures on a voluntary basis if there is no net reduction in farm income. They also wished to remain owners of the land and wanted to receive a stable income if possible generated from the new measures. A more stable income, especially if this can be guaranteed over a longer period, is attractive to farmers. A stable income implies a steady long-term financial benefit that is related to the NFM measures taken.

Eddleston landowner participation process

Tweed Forum has been instrumental in identifying possible locations for NFM measures and then persuading individual farmers to participate in the implementation of NFM on their land (see also https://tweedforum.org/wp-content/uploads/2018/09/NFM_non-tech_clifton3.pdf). This was achieved by working with the project research team on scoping potential sites and then actively involving landowners in discussion of possibilities. Such discussions with farmers were always on an individual basis. Tweed Forum were able to do this as the key staff involved all understand farming as a business and way of life, and because over the years Tweed Forum has come to be recognized and trusted by the farming community.

A key part of the process entailed Tweed Forum making a business case to each farmer which explained how the capital and maintenance costs (and any associated income) from an NFM measure could be made at minimum cost-neutral and, where possible provide a small positive income. All capital costs were covered by Tweed Forum through the various funding mechanisms and grant sources described. Maintenance costs thereafter were covered by the farmer supported, where relevant by the respective grant cost scheme.

Ecosystem service benefits

In 2019, JBA and the project team conducted an initial economic analysis of ecosystem service (ES) benefits based on the NFM measures that had then been implemented as part of the Eddleston project at that time. This included 225 ha woodland created, construction of 28 ponds and 116 flow restrictors/log dams (JBA, 2020a). It should be noted that this initial work was focused on exploring the additional ecosystem services benefits that could be provided by NFM measures, and not on the benefits/damages avoided of their effectiveness in reducing flood risk itself. This and a wider assessment of costs and benefits across all environmental, social and economic aspects is the subject of ongoing work by the project with Mott MacDonald.

The study as performed by JBA consulting consisted of a first appraisal of potential relevant wider ecosystem service benefits, as agreed by the project team. Focus was subsequently on a limited number of ecosystem services, and on direct and indirect economic benefits, not including e.g. effects on employment, or the allocation over a wider geographical area or social groups. As noted, there is an additional study ongoing that determines how a social-cost benefit assessment can be done with a focus on NFM. This will deliver a framework for integrating assessment of NFM costs and benefits within 'standard' processes for Flood Scheme Options Appraisal to be completed later this year.

No detailed studies have been conducted in the Eddleston on key value parameters. So key figures were taken from other studies and areas, and transferred to the project – a standard methodology for assessing ecosystem service values in many studies. Figure 4 shows the benefits under different scenarios as estimated by JBA (2020a). It shows that the total economic value of ecosystem services provided by NFM measures is mainly dependent upon the benefits associated with carbon sequestration and timber production. Both depend on assumptions such as forest management, market and carbon offset prices. All net present values also depend on the discount rate used. These benefits do not yet include the benefits of flood risk reduction or recreation which can also be substantial.

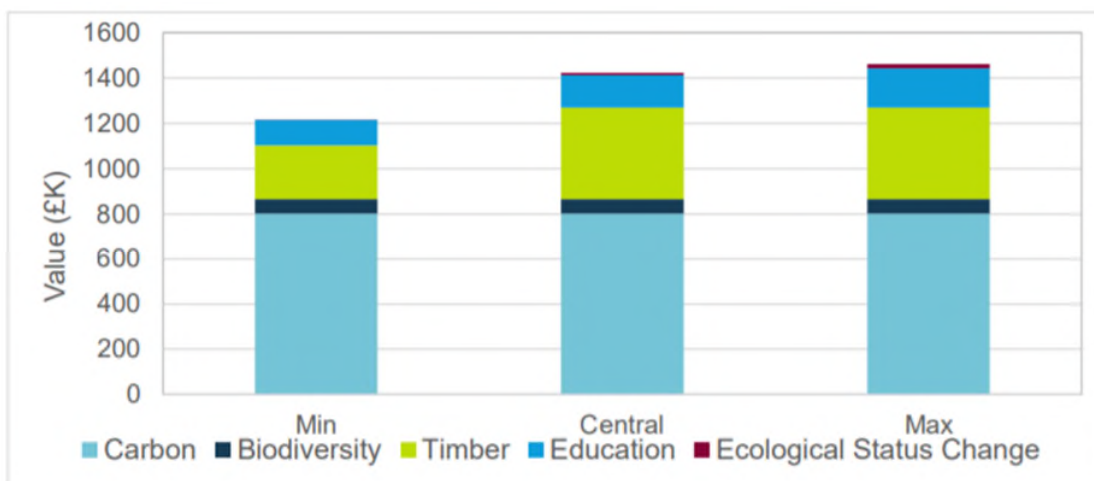


Figure 4. Values of ecosystem services under min, central and max scenario over thirty years. Figure obtained from JBA (2020a).

The study did not calculate the costs of implementing and maintaining NFM, however it included the agricultural income foregone to farming because of the conversion of land use, of which the loss of agricultural subsidies is a large part. The agricultural income foregone was estimated in the order of £304k (over 30 years) to £476k (over 100 years) NPV.

JBA estimates the wider ecosystem service benefits associated with the implemented NFM measures in the Eddleston Water catchment in the range of £914- £1,158k over a thirty-year period. A substantial part of these benefits are associated with timber production, which depend upon assumptions regarding woodland management practices. Without thinning, the wider ecosystem service benefits would drop to £649-822k. However, benefits associated with increased recreational use following catchment improvements and health benefits associated with this, are not included and their maximum economic value over a thirty-year period could be as high as £748k if, for example the proposed new Cycle route is developed along the old railway line, as proposed by Sustrans. Furthermore, the benefits of carbon storage could potentially be much larger if carbon off-set prices would increase in the future.

Lessons learned

Developing a specific business case

There are marked differences between the Eddleston case and most other cases in the BwN INTERREG project. Most of the coastal cases focus on larger individual projects such as large-scale sand nourishments, or a major upgrade of primary flood defences, such as the Twin dike. These latter cases require a project-centred approach in which the optimization of the design of such a project is a major activity. Eddleston, and other cases that seek to apply NFM for flood risk reduction along smaller rivers, require a wider catchment-based approach. In addition, the Eddleston study was set up as a research platform and partially in response to a Scottish Parliamentary Committee on flooding that recommended that 'the government establish further pilot studies to assess the contribution that natural flood management measures can make at the catchment scale' (Spray *et al.* 2009).

Cases along the coast and along larger rivers, such as featured in the Room for the River Program, are characterized by a top-down approach. The problems to be solved in these projects are best solved by putting measures in very specific locations, such as erosion hot spots or weak sections of dikes, and can therefore not depend on the complete voluntary participation of local landowners. Furthermore, the costs of major upgrades of coastal and flood defences are mainly in the building of infrastructure and less so in land acquisition. Also, the compensation money often constitutes only a small part of the total costs of these projects. The Eddleston case is different since it focusses on implementing many small scale measures in a wider area, that can have large implications for the business model of individual local landowners, and their desired effects are not necessarily restricted to a limited number of locations. The application of NFM in Eddleston therefore focused from the start on the voluntary participation of farmers and landowners in accepting NFM measures on their land, and assessing how effective such measures could be. In assessing the contribution that this could make to reducing flood risk, and also improving river habitats, the work was extended to assess the costs and benefits that such NFM measures also provide in the form of additional ecosystem services. As noted, the Eddleston pilot was not set up as a business case, but mainly as a research project, so the potential of transferring potential ecosystem service benefits into potential financing for the scheme has so far not been extensively explored.

Opportunity mapping can be catchment-based or project-centred

Because of these differences, the phase of identifying opportunities for Building with Nature is very different in project-centred and in catchment-based approaches, such as Eddleston. Opportunity mapping in catchment-based approaches has a primary focus on identifying suitable locations for potential NFM measures, ideally within a wider context of catchment development. The potential effects and also acceptability of NFM measures is often location specific within the catchment and depends on specific catchment characteristics and related differences in land-use and land management. In the UK there is a long tradition in identifying the need and potential of measures for flood reduction e.g. by using GIS based information complemented by hydrological models in latter stages. Work is also being done on assessing the ecosystem service benefits associated which will help to identify these potential benefits as part of the mapping the opportunities for NFM.

Opportunity mapping for larger project-centred cases is different. It focusses less on the potential location of the project, since it is often quite obvious where action is needed and there are often no alternative locations. It focusses more on how a specific project in a specific location offers opportunities to achieve and integrate other local and regional ambitions into the project design and hence its financial architecture. It may also consider what win-wins can be achieved by the joint implementation with other projects nearby, for example by recycling materials, joint operation of machinery or sand burrows.

The business case for NFM needs to be based on wider ecosystem service benefits

The first initial assessments of costs and benefits show for the Eddleston case that the economic benefits of flood risk reduction and ecological restoration are substantial but alone may not be sufficient to create a positive economic and financial business case. For Eddleston, the wider ecosystem service benefits associated with carbon sequestration and timber production, along with those from recreation, appear to generate much larger economic returns than those purely from flood risk reduction. And whilst not a factor in the Eddleston case, in other catchments similar benefits from water quality improvements achieved alongside NFM measures may also be far greater than those from NFM alone. Hence the business case for NFM is greatly enhanced and improved by inclusion of consideration of these wider ecosystem benefits as well. However, we must stress that NFM is seen as part of a wider approach to 'Sustainable Flood Risk Management' at the catchment scale; an approach that includes traditional, hard flood defences, as well as flood warning schemes and insurance, as mentioned in the recently updated policy document (The Scottish Government, 2019).

It is therefore vital that the full range of benefits are duly recognized, quantified and that they play a role in catchment development scenarios that focus on the total added value NFM may generate for a catchment and local communities. It is also vital that these are recognized early in the planning process. Work in Eddleston is now underway to assess these wider ecosystem services costs and benefits, and also to determine how best to incorporate the evaluation of these within standard Flood Scheme Options Appraisal processes in local and national government. This may also have implications for opportunity mapping for future upscaling, since most wider ecosystem services benefits are very location specific. Also, the costs of implementing NFM depend on location. The agricultural income foregone depends mainly on the land use that is present, but also the construction of various natural flood measures differs within the catchment and landscape. So, opportunity mapping may need to consider costs as well as effects, and mapping opportunities for NFM may become mapping of potential locations where NFM contributes to the full range of ecosystem service benefits.

Payments for the provision of public services are essential to support delivery of ecosystem benefits in implementation of NFM

Several financial schemes are available in the UK/Scotland that can be used as payments for the provision of public ecosystem services; indeed the very basis of farm subsidies is precisely that - payments for the delivery of what the public desires (up until now mainly focused on good quality, affordable food, the supply of which is secure). Thus, the Scottish Rural Development Programme and other available schemes have been used, along with private capital and grants to finance the investments costs of the Eddleston pilot. However, not all wider ecosystem service benefits are justly recognized in assessing flood protection schemes and their potential to contribute to a positive business case and to financing is not always made clear. This is partly related to the way flood protection schemes are handled, as a single purpose project and not as part of a wider catchment development plan.

Building a business case for the application of NFM on a catchment scale may require the development of additional public support mechanisms and schemes that are based on expected ecosystem service benefits that are attractive enough to farmers and landowners, so they participate on a voluntary basis. The willingness of farmers to participate in NFM will be limited when their costs are not fully compensated. As indicated, farmers prefer measures that generate stable and guaranteed incomes and they want to remain in control of their land. It is a matter of discussion whether large agricultural subsidies for ongoing land use may be re-allocated in a way that they generate different benefits for the wider public, such as flood risk reduction to catchment communities, whilst fairly rewarding farmers for 'farming for flood protection'.

The combination of NFM as part of hybrid solution has a great potential

Building a business case for the reduction of flood risks will require the exploration of hybrid solutions, in which NFM are combined with conventional measures, flood resilience and flood insurance. In Scotland 80% of the flooding capital grant available each year is allocated to large scale projects and distributed according to the prioritisation of flooding schemes and works set out in the 14 Flood Risk Management Strategies

(published in December 2015). However 20% (in 2020-21 £8.4 million) is divided among the 32 local authorities to contribute to the other actions, such as NFM, contained in the Strategies. In the case of the extreme events, the effects of NFM are limited, and will not be sufficient to reduce critical flood risks. There are also limits to what can be achieved on a voluntary basis. In addition, the potential to implement some measures such as the planting of trees at the scale at which they could make a difference may in some catchments be limited because of the already high existing forest cover or the wish to maintain some of the open landscape. This reveals difficult 'trade-offs' that must be considered. New forests take time to grow before their beneficial effects become apparent which may also raise challenges to meeting safety standards within the desired timeframe. Hence solutions that use NFM for flood risk reduction need to explore combination of measures. Since most NFM measures contribute to substantial wider ecosystem benefits for the catchment and the catchment community it appears logical to always explore to what extent NFM can contribute to flood risk reduction.

Building with Nature is building with people

The work of Tweed Forum in informing and negotiating with farmers on the implementation of NFM but also for securing the necessary finance was a critical success factor. The application of NFM needs comprehensive catchment planning and a bottom-up planning process that involves not only governmental and research institutions and NGOs but also local stakeholders. Building such an organization that can work as a 'Trusted Intermediary' is the first step to building a business case for building with nature.

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