Summary of research on developing a more integrated approach to land and water management using incentives and regulations for the delivery of multiple benefits: exploring national and regional level stakeholder views and needs

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Glossary

Term	Definition
Adaptive management	Involves the integration of project design, management, and monitoring, to provide a framework to systematically test assumptions, promote learning, and supply timely information for management decisions. It requires involvement of stakeholders and partners.
Agri-Environment Climate Scheme	A scheme under the Scottish Government Scottish Rural Development Programme 2014-2020. The Agri-Environment Climate Scheme promotes land management practices which protect and enhance Scotland's magnificent natural heritage, improve water quality, manage flood risk and mitigate and adapt to climate change.
ArcGIS	Software for the production and sharing of maps https://www.arcgis.com.
Bag limits	Limit on the number of animals e.g. geese that can be killed by hunters and fishermen.
Catchment	The area from which rainfall flows into a river, lake or reservoir.
Cost benefit	Relates to or denoting a process that assesses the relation between the cost of undertaking and the value of the resulting benefits.
Dashboard	A graphical summary of various pieces of important information typically used to give an overview of a business.
Diffuse pollution	Pollution arising from land-use activities (both urban and rural) that is dispersed across a catchment, or sub-catchment, and does not arise as a process effluent, municipal sewage effluent, or an effluent discharge.
Environmental Co-operation Action Fund	A scheme under the Scottish Government Scottish Rural Development Programme 2014-2020. The Environmental Co-operation Action Fund promotes the delivery of landscape-scale environmental projects by groups of farmers, foresters and other land managers.
General Binding Rules	The Water Environment (Diffuse Pollution) (Scotland) Regulations are referred to as the Diffuse Pollution General Binding Rules (DP GBRs). The DP GBRs focus solely on rural land use activities. All rural land users have a responsibility to ensure they are working in line with these DP GBR's. Developed from widely accepted good practice guidance, such as the Prevention of Environmental Pollution from Agricultural Activity code, the DP GBRs present a statutory baseline which should provide a general level of environmental protection and contribute significantly to water quality improvements.
Geographic information system	A computer application for capturing, storing, checking, and displaying data related to positions on the Earth's surface. It can show many different kinds of data on one map. This enables people to more easily see, analyze, and understand patterns and relationships.
Landscape level	Refers to a level of management focus that is larger than an individual farmer's field.
Outcome logic modelling	A graphical way to present and understand the relationships and linkages between strategies and actions, intermediate results and desired outcomes.
Multiple benefits	Consider the delivery of more than one single benefit e.g. nature conservation or food production from land and water management. One objective of the Scottish Land Use Strategy is to deliver multiple benefits from our land.
Participatory GIS	A participatory approach to spatial planning and spatial information and communications management.
Rural Payments and Inspections Division	Under current European Union (EU) regulations, they must carry out a number of farm inspections each year to confirm that conditions are being met in return for payments made under the various schemes they manage.
Server	A computer or computer program which manages access to a centralized resource or service in a network.
Strategic Research Programme	The Strategic Research Programme responds to the need for cross-cutting evidence to inform policy by facilitating collaboration across scientific disciplines and between Main Research Providers, and through partnership working with other UK funders of research.

Executive summary

This research summary reports on interviews with 13 national and regional level stakeholders in Scotland and their views on: **developing a more integrated approach to land use and catchment management using incentives and regulations for the delivery of multiple benefits, their awareness and understanding of adaptive management and logic modelling, and their suggestions for candidate catchment case studies.** These interviews have informed our initial review of software options that could be used to develop a digitally facilitated outcomes-based approach.

Views on how to develop a more integrated approach were grouped into support for the concept, progress to date based on experiences from the land manager to national levels and the challenges faced, and what was needed to develop a more integrated approach to enable changes resulting in delivery of greater levels of multiple benefits. In general there was support for developing a more integrated approach for the delivery of multiple benefits from all of the interviewees. Though there was support for the concept and examples of its implementation, all of the respondents commented there were improvements to be made and challenges to be overcome. There were a range of suggestions on what was needed to develop a more integrated approach from the land manager to national policy levels to enable change: including flexible use of range of components e.g. SRDP; a central role for facilitation, partnerships and communication; and support from evidence and tools.

The interviewees were asked about their awareness and understanding of adaptive management and logic modelling. These questions followed on from the production of two reports on adaptive management and logic modelling in 2016. Most of the interviewees were aware of the concept and practice of adaptive management, and several of them had been involved in projects that involved adaptive management. A smaller group of interviewees were less familiar with the concept, but they were able to relate adaptive management to their work on land and water management. Two main challenges to carrying out adaptive management surfaced: 1) different understandings of what is adaptive management, and 2) the practicalities of carrying out adaptive management in the field or during policy development. None of the interviewees were familiar with the terms 'results chain' or 'logic modelling.' However all of the interviewees were familiar with outcome-based approaches. Despite this high level of awareness and understanding about outcome-based approaches, a number of challenges were highlighted by the interviewees. These included setting out an outcome-based approach and defining outcomes, and the relative inflexibility of existing targets or desired outcomes. During the interviews it was clear there was a need for a coherent approach to identifying outcomes, including the importance of spatial targeting of interventions to achieve desired outcomes, and the need for monitoring and reviewing of outcomes.

A range of catchment locations were suggested as potential case studies and these could be labelled with one or more of four categories. These categories were established catchment initiatives, locations within national parks, surface waterbodies with important regulatory and policy focus, and other areas of Scotland.

The first phase of tool development has been informed by these interviews, the authors' integrated and participatory modelling expertise, and feedback from related projects. This has guided initial exploration and selection of software options based on a set of seven criteria that included free access for all users, and potential for a Google map-like experience.

1. Introduction

This report provides an update from a RESAS Strategic Research Programme (SRP) project focussed on how we can understand and improve the management of Scotland's land and freshwater resources for multiple policy and management outcomes for the delivery of multiple benefits. It follows on from two earlier reports on adaptive management[1] and logic modelling[2]. Here we summarise our research which has focussed on interviewing national and regional level stakeholders in Scotland to learn about their understanding and requirements for managing land and freshwater resources for multiple benefits. These interviews have informed the first phase of our development of a digital tool to support land management for multiple benefits.

2. National and regional level policy and management stakeholder interviews

Thirteen semi-structured telephone interviews were carried out between February and March in 2017, with representatives from national and regional level organisations involved in setting and delivering policies and management of Scotland's land and freshwater resources for a range of policy and management outcomes. A list of these organisations is provided in Appendix 1. The organisations span a range of perspectives including land managers, Scotland's two national parks, conservation organisations, Scottish Government, SNH, SEPA and Scottish Water. The interviewees were asked for their views on developing a more integrated approach to land use and catchment management for the delivery of multiple benefits, about their awareness and understanding of adaptive management and logic modelling, and suggestions for candidate catchment case studies for future SRP research. The interview transcripts were then coded and themes extracted based on the questions asked to summarise their responses.

2.1 Views on how to develop a more integrated approach to land use and catchment management using incentives and regulations for the delivery of multiple benefits

Views on how to develop a more integrated approach were grouped into support for the concept, progress to date based on experiences from land manager to national levels and the challenges faced, and what was needed to develop a more integrated approach to support changes resulting in delivery of greater levels of multiple benefits. It should be noted that our deliberate use of the broad expression 'a more integrated approach' was likely to mean different things to the interviewees depending on their background and areas of expertise.

2.1.1 General level of support for the concept

In general there was support for developing a more integrated approach for the delivery of multiple benefits from all of the interviewees: for example a land manager representative said "as an organisation we are pretty much signed up to the idea that we need to move towards more

[1] Macleod, C.J.A., K. Blackstock, K. Brown, A. Eastwood, A. Gimona, K. Prager, and R. J. Irvine. (2016). Adaptive management: an overview of the concept and its practical application in the Scottish context.

[2] Macleod, C.J.A. (2016). How can logic modelling improve the planning, monitoring and evaluation of policy measures and wider interventions for multiple benefits?

integrated approaches to land use", they went on to say "for me it is an important way of deconflicting land use." A Scottish Government policy interviewee said "I think it is essential that somehow they are pulled together for multiple benefit purposes." A colleague from SEPA mentioned "we have been thinking for some time that we need an integrated approach for incentives, regulation and voluntary measures (…) and the balance is key"; for example, "in order to see particular incentives and success of measures then we need to determine the outcomes, so we need to monitor the effectiveness, and in some specific geographies and policies see how successful." The same SEPA interviewee suggested "it would be more helpful to have a more structured way, it varies a lot." They said this was more than a checklist to judge success related to "have we delivered more ecosystem services, and what are the trade-offs (…), and how does a land manager do this?" A representative from Scottish Water said it seems that "everyone does their own thing", and went on to suggest it would be good to have a set process outlining the best approach. A national park representative mentioned the economic benefit of a more integrated approach "we are in a pretty challenging economic environment, and efficiencies to get a place based approach in catchments with problems that I believe is probably quite an efficient way to go."

2.1.2 Progress, experiences and challenges faced

Though there was support for the concept of greater integration and examples of its implementation, all of the respondents commented that there were improvements to be made and challenges to be overcome. For example a national park representative said "I think we still have a long way to go in this regard, I have to say I think policy is kind of heading in right direction, so Land Use Strategy as laid [out] is setting a good policy framework", they went on to say "I think it means little to the private sectors." Several of the interviewees provided place-based examples of where progress was being made. The most widely cited example was the Borders regional land use pilot that "did not look through a particular land use lens, it looked at lots of different combinations of land use, and combinations of benefits that those land uses would deliver", a wildlife organisation representative went on to highlight how the Border's pilot had used a "tool and model to retrospectively look at SRDP applications and agreements to see if that approach would have changed how that money was targeted." A Scottish Government policy interviewee highlighted that the work of rivers trusts like the Tweed Forum, Forth Fisheries Trust, South Esk Trust and Dee Catchment Partnership "should be encouraged (…) these people who are driving those approaches are going against the flow, and I think they should be supported whenever possible." Other examples of place-based approaches to managing land and water for multiple outcomes included the Strathard community partnership.

In practice an integrated catchment approach was viewed as difficult, for example Scottish Water are revising their Sustainable Land Management incentive scheme as their previous approach had "been too widespread to be able to pick up improvements" in water quality. Comments from one national park representative said "some of what is already out there is effectively competing against each other to prevent you delivering multiple benefits", for example "if you look at agricultural and forestry funding and how it can deliver with one hand and take from the other." A Scottish Government policy interviewee highlighted that landscape scale coordination was "quite difficult to achieve at the moment, basically because of the numbers of people involved", and the challenges of coordinating hundreds of farmers. They went on to say "we are doing it at a catchment scale bit by bit", but "that's the difficulty, there is not a body that can actually probably take on the whole organisation of doing it at a catchment scale at the moment." A colleague from SNH questioned "are

people really interested in integrated land management, or just interested in their particular aspects being protected and expanded?"

The central role of government policies in driving a more integrated approach was clear. For example the Land Use Strategy, and in particular, the land use pilots, were praised by a wildlife organisation representative "as a mechanism, they are quite strong, looking at potential different interactions of different land uses, and identifying the combinations of land uses that may deliver multiple benefits." The representative went on to say however, "there are some species and habitats that require a very specific, very targeted management." Another respondent set out how "our approach to natural flood management, it must deliver multiple benefits and that is completely embedded" in the implementation of the Flood Risk Management Act 2009.

Related to the role of government policy is the system of regulations and financial incentives for land and water management in Scotland. Several of the interviewees talked about the Scottish Rural Development Programme (SRDP), and the importance and challenge of financial mechanisms for delivering multiple benefits. There were suggestions from several respondents that SRDP could be improved: one land manager representative stated "it is so bureaucratic and prescriptive." A national park interviewee supported this view, "one of the problems we have is the inflexibility of things like SRDP to be able to react to local circumstances which means a certain number of people kind of just walk away", and they went on to say "it has to be truly adaptive and flexible to work." A Scottish Government policy representative highlighted the importance and challenges of SRDP as a financial mechanism to incentivise farmers and land managers for multiple benefits "we find these kind of incentives, it is quite difficult to get any action on the ground"; that with budgets at government and local level it can be "very difficult to actually pull together for multiple benefits." One SNH representative said "we were hoping that [Environmental Co-operation Action Fund] ECAF would help with that, but again ran into problems with funding on that one." There was limited time to develop "a scoring system that would allow you to look at multiple objectives" and "almost everyone involved in doing it, had expected an application to be able to address more than one priority", they also highlighted that what you "can do with European funding is quite restrictive." Suggestions from a land manager representative included to "better link [General Binding Rules] GBRs to cross compliance" and "better coordinate where regulation needs to be strengthened or in a lot of cases the regulations is strong enough, it just needs to be enforced", and they went on to say "it might be easier to enforce if you can show the wider benefits." A wildlife representative made the point that there was a disconnection between "what we ask land managers to deliver and what is needed, climate change is an example of this, in the current climate change plan agriculture has very low targets" for emission reductions.

2.1.3 Views on what was needed to develop a more integrated approach

What was needed to develop a more integrated approach across these levels to enable change included a range of components to be used flexibly; with a central role for facilitation, partnerships and communication; supported by evidence and tools that have been tested and demonstrated in place-based studies.

2.1.3.1 Enabling change from current situation

To enable a more integrated approach to deliver multiple benefits there is a need to understand and work across multiple levels/scales and sectors. For example one wildlife representative highlighted

that integration is “not just about on the ground connections, also policy connections.” One Scottish Government policy interviewee said there was a need for a clear strategy to be able to “do it at a catchment scale,” as well as evidence to “convince us that at a catchment scale it could be achievable.” To enable change to take place in how land and water is managed, a land manager representative summarised “if you want people to make change to their business, they need to understand why, they need to understand what’s in it for them, they need to understand how, and you need to give them space, and the headspace to reach those decisions.” Another land manager representative said “rather than taking this very sort of niche approach, that we do our sectoral approach” there is a need to move towards a situation where we get a better balance, and improved understanding across sectors.

2.1.3.2 Flexible and balanced use of a range of incentives and regulations

Enabling this change to take place requires flexibility and balance in how regulations and incentives are used to achieve outcomes that span multiple benefits. One national park representative said it is “pretty evident that you need both support and regulation tools to be effective, one doesn’t work without the other, because the private sector and the open market doesn’t really react unless you kind of have both.” A Scottish Government policy interviewee highlighted “I do not know of any one component which can play the greatest role to organise it at the moment”, and illustrated their point in relation to ECAF saying “I still struggle to see how that would cope if it was on a very large scale” with one ECAF or would it need to be in a catchment with 10 different little ECAFs?”

2.1.3.3 Importance of communication, facilitation and partnerships

The key role of effective communication, facilitation and partnerships for enabling change in land and water management to deliver specific outcomes was stressed across all the interviews. A land manager representative stated two key points, the first that “farmers are happy to talk, but they do not want to sit” and discuss topics like natural flood management for a whole day “it is just not in their DNA”, and that land managers have limited time to absorb new information to support their decision-making. They provided an example of good communication practice where the “diffuse pollution priority catchments have put that information in front of the farmer in a very digestible way, a very personable way and have signposted where the financial help and guidance is available (…) rather than, you know well we have produced a leaflet surely they should just get on and do it and understand what’s required of them.” A national park representative raised the “need to talk the language of business so that farmers, estate owners, foresters, local communities, government agencies can get around a table.”

As part of communication several interviewees mentioned the import role of facilitation, this was illustrated by one national park representative “you need to have ways of facilitating a joined up approach to integrated management (…) focussed on overcoming problems and issues.” A SNH representative highlighted the importance of facilitation for “trying to get some of those things happening on the ground.” An exemplar is the work of the Tweed Forum and the Borders pilot where there has “been a lot of developing of opportunity maps and discussion with stakeholders what they would like to see happen.” They stressed the need to have people who are able “to liaise with land managers and access funding to achieve things on the ground is really crucial, and is what we have struggled with in other places.” The SNH representative stressed “it is a way of working that we want to encourage.” The importance of facilitating discussions with land managers about financial incentives to achieve the desired change was illustrated in relation to natural flood

management by one land manager representative “there needs to be the financial mechanisms for this to happen, and the farmers need the advice and guidance.” For example, after a local authority has identified a flooding problem and some land that could help alleviate it, there is a need for a “very early no strings attached conversation (…) with the farmer and say right we have a problem here, we think you can be part of the solution, in theory are you interested, here is what we can offer you.”

Related to communication and facilitation was the role of partnerships across relevant organisations and groups. One SEPA interviewee said you “need to understand what other organisations are trying to deliver to” i.e. what are they trying to achieve. A national park representative highlighted the need for “partnerships across land holdings”, they went on to say “I think the effective scale for that is catchment or sub-catchment.” There are other examples of organisations working together in partnership to deliver multiple outcomes for example Scottish Water worked with SEPA in their priority catchments and “offered to give the farmers some financial incentives to try and help improve water quality.” One area of particular interest for Scottish Water sustainable land management team is peat restoration. This work would take “an integrated approach working with other parties” to deliver drinking water quality outcomes, and other environmental benefits. A couple of interviewees talked about the importance of rolling out of the regional frameworks across Scotland as this “could be a really effective mechanism for ensuring that we do better target public subsidies where they have most impact” and to meet government targets delivering multiple benefits, “for example forestry planting and peatland restoration some of which potentially could be conflicting, it they aren’t planned for properly.” A representative from SNH also stressed the benefits of regional partnerships “where there is coming together of stakeholders to discuss these kinds of issues in an area, and come up with proposals with what they would like to see happen in a particular geographic area (…) across a range of land uses and a number of different sectorial interests.” One national park interviewee suggested greater use of rural land use partnerships, where “I would like to see a place-based team which had the relevant expertise from the national park authority, SEPA, SNH, Forestry Commission, and RPID who would work together from an agency level (…) deliver the best kind of benefits and not step on each other’s toes, be efficient, work with local communities and local land owners.”

2.1.3.4 Role of evidence, knowledge and tools

Several interviewees talked about the need for evidence on the benefits and outcomes of land and water management, and their requirements for practical and accessible tools to support the desired changes. For example one national park representative said we “need to be clear what are the public benefits and need science evidence how [management] leads to those.” They illustrated this point with reference to “hare counts and this evidence helps us to provide evidence to estates” about their management. One SEPA colleague called for “better understanding of potential of measures for multiple benefits”, and they highlighted this referring to measures like field banks and hedgerows “have potential for multiple benefits for flooding, soil erosion, all of these only if they are put in the right place.” A couple of SNH and SEPA interviewees mentioned the long-time scales required for evidence on the effectiveness of river basin management plan measures “the problem is long term, we have not been through a cycle and [are] not able to say why measures are a success.”

Related to evidence was the need for tools, one national park representative stated that "if [you are] asking land managers to change practices, [you] need tools (…) and need to ensure all those factors are monitored and demonstrate leading to improvements." Another national park representative said "the issue is really having the tools to be able to effectively do that." One SNH colleague who has been involved in a wide range of studies looking at land use for a range of benefits asked "can we set up neutral criteria and measure different land uses to that (…) need a number of factors, you can restrict this to a manageable list, then land use X does not score well on money, carbon etc then maybe need something else that comes further up the list." From the interviewees it was evident that tools are needed at the land manager level and at the landscape level to support decisions about management interventions and their potential outcomes for multiple benefits.

The interviewees were also asked about their awareness and understanding of adaptive management and logic modelling. These questions followed on from the production of earlier reports on adaptive management and logic modelling. Summaries of these reports were shared prior to the interviews. The purpose of asking these questions was to gain insight into their awareness and understanding of these concepts, as well as their views and experiences of using adaptive management and logic modelling.

2.2 Summary of awareness and understanding of adaptive management

2.2.1 Awareness and understanding

Most of the interviewees were aware of the concept and practice of adaptive management, and several of them had been involved in projects that involved adaptive management. For example one representative of land managers said "I deal with adaptive management to do with species management on a regular basis", and based on their positive experiences they added "that approach is beginning to be one we are seeking for other species." Another land manager representative suggested "it sort of sums up land management anyway because that is what you do, you try things and if they don't give the output you are looking for, you adapt and change and try again." A nature conservation interviewee said "as an organisation it is something we do a lot", not only for species management, but also for land management "for example, to restore blanket bogs to ensure we are getting biodiversity benefits and also improve water quality".

A smaller group of four interviewees indicated they were less familiar with the concept, but they were able to relate an adaptive management cycle diagram, which I had circulated prior to the interviews, to their work on land and water management: for example a policy interviewee said "well I suppose everything I do (…) is about climate change adaptation more generally." Another who referred to reading our earlier report on adaptive management talked through an adaptive approach to developing and improving specific policies and guidance based on environmental monitoring and other sources of evidence e.g. "if someone asked me do you adaptive management, I would say no, but I suppose in essence I do." A Scottish Water respondent was unfamiliar with the concept of adaptive management, but went on to say "I think some of it we do anyway, but I wouldn't have said that we would have called it adaptive management." Other national level interviewees described their work on SRDP, Water Framework Directive (2000/60/EC) and the Scottish Climate Change programme in terms of an adaptive cycle. One SNH colleague referred to adaptive policy cycle in relation to producing and revising agri-environment schemes based on feedback from Europe, and queries generated by its use e.g. "how much woodland cover you can

have in a water margin, before it no longer becomes agriculturally productive under agri-environment."

Awareness and understanding seemed to be influenced by the scale of the interviewees' focus; in general those working on national level policies had less knowledge or experience of adaptive management of land and water measures, compared to other interviewees more closely involved in land and water management on the ground. Awareness was also greater with those interviewees who's area of work focussed more on species or habitat management, for example due to their involvement in the SNH geese adaptive management pilots.

Several of the interviewees were able to describe key steps and principles often associated with adaptive management of the environment in relation to their experiences of adaptive management. A couple of interviewees commented that adaptive management is often applied in very specific settings (e.g. SNH pilots), for example a nature conservation representative talked about "so the land we own and the land we manage is really where we would deliver adaptive management and trial things, and change them." The importance of evidence for adaptive management was mentioned by several interviewees, one land manager representative said "the bag limits for shooting of Barnacle geese are set with a very strong underpinning of science and monitoring." The central role of communication and facilitation along with the need to work with other individuals and organisations were highlighted by various interviewees. One policy interviewee talked about the Scottish Climate Change Programme as requiring to "link with colleagues in other policy areas, to consider wider adaptation strategies." Adaptive management was also talked about when working with land managers for outcomes by three interviewees, and one highlighted that more than single outcomes needed to be communicated. One wildlife representative said "it is about empowering the land manager to make adaptive changes".

2.2.2 Challenges to the use of adaptive management

Through the knowledge and experiences of the interviewees two main challenges to carrying out adaptive management surfaced: these were different understandings of what is adaptive management, and the practicalities of carrying out adaptive management in a place-based setting or in policy development.

A couple of very experienced SEPA and SNH scientists involved in environmental management highlighted it was "one of those terms that goes by various names depending on the stakeholder group, means different things to different groups." Another interviewee said "I regard adaptive management as a loose term, as something people talk about a lot and they are not always clear what they mean, lets suck and see approach." They went on to say "in SEPA we appreciate adaptive management is needed." A national level interviewee who was very familiar with adaptive management, was "very sceptical of people using adaptive management unless clear in objectives and how measuring."

The second challenge to the application of adaptive management in support of land and water management is its feasibility. One SNH interviewee said "as people promise adaptive management in (…) management, and just doing the status quo, but the other things change like fences going up, changes in agricultural grants and it is all a mush of changes over time, with no real ability to say we did this and measured this, can [we] say this worked?", and there is "very limited use of full adaptive management, with objectives and monitoring as this is expensive. We do not control all the

variables." One land manager representative could see how used for species management, but not for land management; whereas at least three interviewees had experience of adaptive management of land and habitats. A Scottish Government policy interviewee, who was less familiar with adaptive management theory and practice, when asked if adaptive management had a role replied "if we had the time (…) if we had a big enough team (…) yeah it probably would play a role, but at the moment because there is only two of us (…) I think we adaptively manage in our own way."

2.3 Summary of awareness and understanding of results chain logic modelling

2.3.1 Awareness and understanding

None of the interviewees were familiar with the terms 'results chain' or 'logic modelling', for example one land manager representative said "I may have come across them in practice, but I do not recognise the terms." However all of the interviewees were familiar with outcome-based approaches, for example some interviewees went on to say "yeah in policy world there has been a shift towards trying to measure the effectiveness of what we do based on outcomes rather than actions or outputs" and "it is a shift I think that is very positive one actually." A couple of the interviewees made reference to project management terminology, with one national park interviewee saying that this "would be a much more familiar language to many people, many people whether it be from the business or the third sector or public sector I think." Another national park representative said "we would encourage that all maximise public benefit, and first define what public benefit is and ensure management is leading to that." Another land manager representative was more familiar with outcome base approaches "yeh, that would be what we are driving for in these cases." They illustrated this with examples of their involvement in wildlife conflict management "more important is what is the outcome: does that reduce the impact on the farmer or croft (…) to find a way to deliver an outcome that works for farmers, without breaching directives", highlighting that there are financial, social and environmental outcomes. One interviewee said at Scottish Water they were very "outcomes based." They went on to say that any land management work needed to have a defined outcome, as before they "do anything in a catchment it must have a cost benefit, that is the outcome, we want to see improvements to water quality, but that has to be cost beneficial for the customer."

2.3.2 Challenges to taking an outcome-based approach

Despite there being a high level of awareness and understanding about outcome-based approaches, a number of challenges to carrying out an outcome-based approach were highlighted by the interviewees. These include setting out an outcome-based approach and defining outcomes, and the relative inflexibility of existing targets or desired outcomes.

A land manager representative said a challenge was that "in practice people find it difficult to focus purely on (…) outcomes" and not get involved in the actions. This was demonstrated by a national level interviewee who said "we have tried to do that (…) in the agri-environment schemes, that did not go down too well with Europe, they did not like it, it wasn't prescriptive enough for them." They went on to say it was "actually more to do with the inspections." They also highlighted the difficulty of using an outcome-based approach for "influencing work we do, the outcomes can be quite broad and aspirational", whereas short term outcomes might be more easily measured. Another interviewee highlighted that outcomes at the national policy level were often "loosely defined, as we cannot fail, so anything must be a success (…) this limits what public servants will do, that may

actually really fail." Across the interviews there seemed to be a range in their understanding about outcome-based approaches and this ambiguity may limit a consistent approach to their application. Another challenge to managing land and water was mentioned by a national park interviewee "one of the outcomes that is a challenge is the park designated sites, then have Natura outcomes that are set and ability to look at those is limited."

2.3.3 Requirements for developing an outcome-based approach

Through the interviews it was clear there was a need for a coherent approach to identifying outcomes, including the importance of spatial targeting of interventions to achieve desired outcomes, and the need for monitoring and reviewing of progress on delivering outcomes.

In terms of identifying outcomes, a national park representative made reference to the need to "identify what [is] that shared outcome" and then said "we are interested in evidence of those being achieved, and [to] have the evidence that those interventions are having an effect." The importance of spatial targeting of measures was highlighted by an interviewee from SEPA "in terms of diffuse pollution measures, they need to be in the right place for them to be effective." They went on to say "if you were looking at your farm (…) [and] if you were able to look at everything in one go, in one plan that would help you put something in place that not only helped biodiversity (…) could be effective tool for mitigating diffuse pollution." Depending if the level of focus is farm to landscape scale management or national targets, the nature of the outcomes and evidence required to support evaluation of progress to achieving them will differ greatly. For example a national level interviewee talking about a national programme of flood risk management work referred to "that is how I will view and ultimately judge success, and also judge where our barriers are, if these studies fall down or if the schemes do not go ahead, then that is how we will look at them (…) not to be taken through to measures on the ground."

The importance of collecting evidence to measure outcomes and reviewing progress was referred to by several interviewees. One conservation representative was clear for the need to "measure what you are achieving" and "would be concerned about an input based approach (…) we want to look at the impact of our management." This evidence included modelling in relation to desired outcomes that they "are constantly doing and looking ahead, and looking for solutions and using a lot of, range of different data to identify the best management." A national level policy interviewee highlighted the importance of evidence from monitoring programmes and from "knowledge gained by on the ground people" to enable their revisions of land and water management regulations. In addition to the use of outcome-based approaches at local and national policy levels for the management of land and water, interviewees from SEPA and Scottish Wildlife Trust (SWT) mentioned they were using it as part of their corporate planning. The representative from SWT highlighted it "helps if in a dashboard format, [we are] seeing them in digital reports."

2.4 Suggested river catchments for case studies

As part of two linked RESAS projects we are due to carry out place-based case studies in 2018. One of the objectives of these interviews was to collect stakeholder's views on where we should focus geographically. A range of locations were suggested (Table 1), and these fall into one or more of four categories.

The first category covered a number of established catchment initiatives including the Tweed Forum and Dee Catchment Partnership which were mentioned by several interviewees. This was the most commonly suggested category (Table 1).

Table 1. Suggestions of river catchments for case studies

Where	Categories[A]	Who[B]
Aberdeenshire Dee	1,2,3	1,2,4,7,9
Tweed	1,3	1,7,9
Spey	1,2,3	2,4,6
South Esk	1,2,3	7
Forth Rivers Fisheries Trust	1,3	7
Strathard	2	3,8
Loch Lomond	2,3	8
Loch Katrin	2,3	8
Glen Dochart	2	8
Ugie	3	5
Scottish Water drinking water catchments (several hundred)	3	5
SEPA priority catchments (include the bathing catchments below)	3	3,11
Bathing waters with poor quality[C]	3	3,13
South West	3,4	9
Cumbernauld	4	1

A 1-established catchment initiatives, 2- locations within the national parks, 3- key regulatory and policy focus (including Scottish Water drinking water catchments), 4- catchments out with these other areas. B The numbers refer to the interviewees. C Ayr (South Beach), Cruden Bay, Eyemouth, Fisherrow Sands, Heads of Ayr, Kinghorn (Harbour Beach), Monifieth, Nairn (Central), Nairn (East), Portobello (West), Sandyhills and Yellow Craig.

A second group of locations within Scotland's two national parks were advocated including existing initiatives based at Strathard and Loch Katrin, and other locations e.g. Glen Dochart which is similar to "a lot of west and north Scotland is like that, so if you want to find solutions to how the landscape and how private sectors and land use is going to change in the future then places like that are good places to try." A SEPA interviewee suggested "you may have heard of Strathard partnership to deliver multiple benefits."

The third category of locations was those with a key regulatory and policy focus (Table 1). For example one policy interviewee suggested "the bathing water catchments where we have to try and identify exactly where the problems coming from, we have 12 bathing waters classified as poor." Related suggestions included any of the large number of Scottish Water drinking water catchments, more specifically the Scottish Water representative added "areas where we have got concerns for organics" which tend to be upland areas. A SEPA interviewee suggested their priority catchments with the caveat that "we want to make sure we can address problems we want to using measures in general, and [would] be concerned if we have treated one catchment as special", they went on to say "if we looked at adaptive management this should be OK, and did not have lots of extra effort." Another interviewee from SEPA supported this saying "probably catchments where we have been working would be a starting point, catchments where measures have been implemented and have information on SRDP uptake."

A fourth category was catchments in other geographical areas (Table 1). A land manager representative suggested locations in the south west "just thinking about the mix of activity that will go on down the catchment could make them quite interesting." Another example was the periurban catchment at Cumbernauld, as there has been work "with a range of developers to explore [sustainable urban drainage systems] SUDS e.g. ponds and we now manage these ponds for wildlife and improving water quality as part of living landscape, and very multibenefits."

A number of additional points were raised during the interviews, these included: relative merits of working with established catchment initiatives and national parks, specific examples of where and what to focus on, and the need for more information before being able to suggest locations. Advantages of working in a catchment where there has been a large amount of work with stakeholders was set out by one interviewee "if you are looking for somewhere with a head start then working with the Tweed Forum would be the ideal place to go (…) as well the Dee River Catchment Partnership too." The same land manager representative questioned "but whether that would be useful because it is operational and working quite well." A wildlife conservation representative was also in "two minds about this, Border and Aberdeenshire great as part of regional land use pilots, would like to see continue, also like to see focus on other areas." National park representatives made compelling cases for working within their parks as "we have contacts, we have networks you know, we have open doors to help float some of those conversations".

Specific examples of land and water management for multiple benefits were suggested by two interviewees. A representative from the Loch Lomond and the Trossachs National Park highlighted "key things I would like to progress in Strathard is (…) the concept of natural capital accounting (…) to fully understand the resource a bit more, in particular relation to carbon storage and capture in climate change mitigation (…) because at the minute many of them are used largely for one purpose, which is the production of sheep or venison or timber and we seem to be completely ignoring the opportunities and role they play in water storage and carbon storage." A SNH interviewee with expertise in upland management and policy said "not sure catchments are the basis." They went on to talk about the example of deer fence requirements "for new woodland and [since] old ones [are] falling down (…) fence around five ha, rather than intricate mosaic, so create bigger areas (…) use less deer fences." They highlighted this was linked to "catchments as rivers and trees, going to be too hot in the future for salmonids, and bank erosion. Only solution is riparian trees to provide shade and cool water." They highlighted that "Pearls in Peril spent lots of LIFE public money for fences (…) difficult to see how you could extend it in the uplands." They suggested working on the Aberdeenshire Dee "as upper Dee runs east-west and most exposed to summer temps, and on the east for warmer summers" that are predicted in the future.

A couple of interviewees from national level organisations stated they would not be able to provide suggestions at this stage, for example "it would depend really on what the, whether the focus would be, the catchment would depend on whether the main focus be diffuse pollution for example (…) of looking through WFD is it physical barriers (…) that would change where and what." Another couple of interviewees suggested "it depends on what size of catchment level." Another interviewee said "it depends on what kinds of area you are looking at in terms of the topic." A SEPA colleague said "if we knew what you were measuring with the catchments, there are certain catchments we have been working in for several years and know quite well, and probably could help out."

3. Development of a digitally facilitated outcome-based approach

Following on from the steer provided through these interviews and the SRP tender, we are working on the first phase of developing a digital tool to meet stakeholder needs to support individuals (and potentially groups) in their decision making about the multiple outcomes from land management due to agri-environment incentives e.g. Agri-Environment Climate Scheme (AECS). What we develop is to a large extent dependent on who these digital tools are for and for what purpose. The interviews have demonstrated that practical tools to support land and water management for multiple outcomes and benefits are needed at the land manager and landscape levels. The development of these tools will be iterative through relatively short phases of work. Here we set out progress with the first phase of their development that will culminate in a small workshop with non-research and research stakeholders at the end of May (one page outline in Appendix 2). We are focussing on the development of a web-based mapping tool due to the widespread availability and use of these digital tools e.g. SEWeb and other SEPA and SNH map based web pages[3] that have spatial capabilities, and the widespread provision of online data and information e.g. SRDP AECS pages[4].

3.1 First phase of development

The first phase of our tool development has been informed by the authors' expertise in integrative and participatory modelling, and additional Hutton colleagues have shared their experiences of participatory geographic information system (GIS) work with stakeholders using large touch tables. We have narrowed down a longer list of about 20 potential software options (Table 2) to a shorter list of four or five options that we are currently evaluating.

3.1.1 Learning from the experiences of Hutton colleagues

Two Hutton colleagues have shared their experiences of using touch tables for participatory GIS using a standard GIS package called QGIS[5]. The two main limitations both projects found were participants expectations and preferences for interfaces like Google maps, and similar online map applications, with smooth transitions between zoom levels e.g. when navigating from a broad view of a landscape to a smaller area of focus, and vice versa. These GIS applications also required the full time presence of a GIS expert, to navigate its functionality. One of our colleagues with considerable expertise in developing spatial decision support systems, suggested we should develop a web-based tool that could be used online or offline.

3.1.2 Initial review of software options

With the aim to narrow our focus for developing widely accessible web-based mapping tools we have reviewed four broad groups of software options: these were existing adaptive management logic modelling applications e.g. Miradi[6]; existing desktop participatory modelling applications e.g. QUICKscan[7]; GIS modelling applications e.g. QGIS[8]; and a range of software packages and

[3] For example: http://map.environment.scotland.gov.uk/landinformationsearch/lis_map.html
http://www.environment.scotland.gov.uk/get-interactive/data/water-body-classification/
[4] https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/
[5] Free and open source GIS that is loaded onto a computer and has similar functionality to ArcGIS
http://www.qgis.org/
[6] https://www.miradi.org/
[7] http://www.quickscan.pro/
[8] http://www.qgis.org/en/site/

applications for developing web-based applications e.g. R Shinydashboard[9]. A list of the software options and our assessment of them based on our criteria is in Table 2. The two authors developed a set of seven criteria based on the original planned work, their joint modelling expertise, the experiences of other Hutton colleagues, and feedback gained during the interviews. These seven criteria were that the software should enable:

- the tool to be free at the point of use;
- the tool needed to work on touch devices like tablets and touch tables since touch enabled devices are widely used;
- it needed to have map-based functionality for users to interact with spatial information e.g. information on fields and other features related to land and water management;
- it required functionality to include outcome-based logic models i.e. linking land management to a range of outcomes;
- there needed to be flexibility for the authors to develop and extend the software/existing application, since this was a strategic research project there needed to be potential for scientific innovation; and
- the status of the software needed to reflect it was active and being maintained.

The two authors have looked at the information available on these software options and used these criteria independently to assess which options could be explored in more detail, and then discussed their suggested options. From our assessment we are currently exploring the potential of two high level dashboard applications R Shinydashboard and Jupyter dashboard[10], a mobile QGIS application called ROAM[11], and Python based applications (Flask/Django[12]) and JavaScript based applications (Node[13]) that make use of JavaScript libraries for producing maps e.g. Leaflet[14].

Our focus has been on software supporting a web-based spatial dashboard design. Over the past three to five years there has been a transition to these from older style decision support tools that were typically installed on desktop or laptop computers. Some of these non-web-based tools like QUICKscan have been used to support land policy and management work across Europe.

3.1.3 Testing of candidate options for functionality and feasibility

We are currently exploring the potential of these software options to digitally facilitate an outcome-based approach through meeting the expressed needs of stakeholders. At a small workshop in May we will explore stakeholder needs in greater detail, and demonstrate some of the functionality that may support individual and group decision making on land and water management for multiple benefits.

[9] https://rstudio.github.io/shinydashboard/
[10] https://github.com/jupyter/dashboards
[11] https://github.com/DMS-Aus/Roam
[12] https://www.djangoproject.com/ http://flask.pocoo.org/
[13] https://nodejs.org/en/
[14] http://leafletjs.com/

Table 2. Assessment of software options for tool development

Options	Criteria								
	Free to use[1]	Use on touch devices[2]	Interact spatially[3]	Logic model[4]	Develop/ extend[5]	Innovation [6]	Status[7]	Selected: yes or no	Links/notes
Existing adaptive management logic model applications									
Miradi	100-999	No	No	Yes	No	Low	Active	No	https://www.miradi.org/
Mobile version	Maybe[8]	Yes	Maybe	Yes	Maybe	Maybe	Active	No	Not available.
Existing standalone participatory modelling applications									
Quickscan	100-999	No	Yes	Maybe	No	Low-med	Active	No	http://www.quickscan.pro/products
Metronamica	>10000	No	Yes	Maybe	No	Low-med	Active	No	http://www.metronamica.nl/
Geodesign	0	Maybe	Yes	Maybe	Maybe	Med-high	Active	No	https://www.geodesignhub.com/, Limited to the existing geodesign process.
DASEES	0	Maybe	Maybe	Maybe	Maybe	Maybe	Active	No	http://dasees.neptuneinc.org/ Not yet available, structured decision making application.
GIS modelling applications									
Community Viz ArcMap plugin	100-999	No	Yes	No	Yes	Med	Active	No	http://placeways.com/communityviz/index.html
MCDA4ArcMap	0[9]	Maybe	Yes	No	Maybe	Med	Active	No	https://mcda4arcmap.codeplex.com/
EMDS (US EPA)	0	Maybe	Yes	Maybe	Maybe	Low-med	Active	No	http://1726-4482.el-alt.com/aboutemds Not freely available.
Standard ArcMap	100-999	No	Yes	No	Yes	Low-med	Active	No	http://www.arcgis.com/
Standard QGIS	0	Yes with plugin	Yes	Maybe	Yes	Med	Active	No	http://www.qgis.org/en/site/ Issue about large move from version 2 to 3.
ROAM (QGIS app)	0	Yes	Yes	Maybe	Yes	Med-high	Active	Yes	https://github.com/DMS-Aus/Roam
Software packages and applications for developing web-based applications									
Python or Javascript based Leaflet applications	0	Yes	Yes	Yes	Yes	High	Active	Yes	Meets many criteria, will take more effort to develop

Options	Criteria								
	Free to use[1]	**Use on touch devices[2]**	**Interact spatially[3]**	**Logic model[4]**	**Develop/ extend[5]**	**Innovation [6]**	**Status[7]**	**Selected: yes or no**	**Links/notes**
Kivy	0	No[10]	Yes	Maybe	Yes	High	Active	No	https://kivy.org/#home
R Shinydashboard	0	Yes	Yes	Yes	Yes	High	Active	Yes	https://rstudio.github.io/shinydashboard/
Jupyter dashboard	0	Maybe	Yes	Yes	Yes	High	Active	Yes	https://github.com/jupyter/dashboards
Tableau	0	Maybe	Yes	Maybe	Maybe	Med-high	Active	No	https://www.tableau.com/ Not sure if it can be used off line.
Spotfire	1000-9999	Maybe	Yes	Maybe	Yes	Med-high	Active	No	http://spotfire.tibco.com/
Plotly	100-999	Maybe	Yes	Maybe	Yes	Med-high	Active	No	

1 Approximate cost (£): 0, 1-99, 100-999, 1000-9999, and >10000; 2 Is the user interface designed for non-expert/group touch screen i.e. is the navigation easy to use: yes or no; 3 Is there part of the screen that includes a map: yes or no; 4 Can logic models potentially be viewed and edited: yes or no; 5 Can the project team with their Python, R and JavaScript expertise develop the application and extend it: yes or no; 6 What is the potential for scientific innovation: low=old application and widely used, med=established application but not widely used, high=new application; 7 Is it still being supported: inactive= little evidence of activity over the past year, active= evidence of activity over the past year; 8 A 'maybe' indicates that information was not available to judge against these criteria; 9 ArcMap not free to use; 10 Not on Windows devices.

Appendices

Appendix 1: A list of organisations involved in the interviews

Interviewees from the following organisations were interviewed: Cairngorm National Park Authority, NFU Scotland, Loch Lomond and The Trossachs National Park, RSPB, Scottish Land and Estates, Scottish Water, Scottish Wildlife Trust, SEPA, Scottish Government, and SNH.

Appendix 2: Draft plan for the workshop

Workshop invitation: developing a digitally facilitated outcome-based approach for understanding the effectiveness of interventions in catchments for multiple benefits

Aim

Our aim is to work with a small group of national and regional level expert stakeholders (and researchers) to discuss their needs as part of our development of a digitally facilitated approach to outcome-based assessment of the effectiveness of land management interventions (including SRDP measures) in catchments for multiple benefits[15].

Workshop objectives

1) To improve our understanding of national and regional level stakeholder's perspectives on what is needed from an outcome-based approach to aid individuals (and groups) to make more informed decisions on land and water management interventions for a range of outcomes.
2) To explore and discuss key principles and functionality of a digital facilitated outcome-based approach.
3) Demonstration and discussion of relevant digital applications and their functionality, and one or more prototypes to guide how we could develop and apply our approach.
4) To help steer the development of our approach and produce a workshop summary.

Where and when

At the James Hutton Institute in Aberdeen (http://www.hutton.ac.uk/about/directions; Macaulay A Boardroom) on 23rd May 12.30 (lunch for visitors) for a prompt start at 13.00 (finish at 16.00).

Background

Recent interviews with stakeholders highlighted the need for practical tools to facilitate decision making about land and water management based on the range of outcomes they provide. Digital dashboards and related web-based applications are increasingly being used to present spatial information on the state of land and water resources, and their management to a range of audiences in support of decision making[16]. This workshop is part of the RESAS Strategic Research Programme[17], a summary of planned deliverables provided in Table 1.

Table 1. RESAS deliverables related to this workshop.

Deliverables	Timescale (due)
Stakeholder workshop on approach (D3.4/KE8).	Summer 2017
Outline of revised approach (D3.5).	Summer 2017
Short draft report and database on effectiveness of interventions (WFD). Based on feedback develop the approach in context of WFD and RBMPs including digital version of logic models (D3.6).	Spring 2018
Revised report and database.	Autumn 2018
In years three to five apply our approach in catchments with a WFD focus, including SRDP measures and drinking water protected areas.	2018-2021

[15] We use multiple benefits in a broad sense to mean more than one potential benefit to the environment, land manager or wider society. The term multiple benefits is widely used by policy and management stakeholders in Scotland e.g. in the Land Use Strategy.

[16] An example from SEPA is the WFD RBMP information http://www.sepa.org.uk/data-visualisation/water-environment-hub/

[17] This research is part of two linked projects: RESAS 1.2.4 Effectiveness of water management, Objective 3: Assessment of the effectiveness of interventions to achieve increased effectiveness of water policy objectives; and RESAS 1.4.3 Practical interventions to realise multiple benefits and manage trade-offs. Objective D: To use adaptive management (AM) to integrate SRDP interventions with Natural Flood Management (NFM) and General Binding Rules (GBR) for the delivery of multiple benefits.