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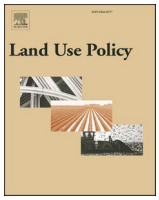

Obstacles to local payments for ecosystem services schemes for water management at the catchment scale: A case study from Eastern Scotland

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ABSTRACT

Water catchment management negotiates a complex landscape of local and expert knowledge, cultural and historical norms, property rights, and the pressures of environmental change. Various schemes have developed in recent years that aim to provide an integrated, consultative approach to environmental management, among which payment for ecosystem services (PES) has emerged as a successful example. Yet, there are certain characteristics of catchment landscapes that problematise the implementation of PES schemes for water management. This paper explores these characteristics in a case study of the Lunan water catchment area in Angus, Scotland. We report on a scientific research project to develop and implement a tilting weir system in the catchment that aims to address wetland nutrient and sediment pollution, winter flooding in the upper catchment, and summer water shortages in the lower catchment. Socio-scientific methods investigate the potential use of a PES approach to support the local management of the tilting weir system for the provision of multiple benefits at the catchment scale. Research shows evidence of conflicting levels of support between farmers and residents for both the intervention itself and the PES approach, diverse perceptions of rights and responsibilities in relation to water, and the challenges of identifying an adequate PES intermediary in the current institutional framework.

1. Introduction

The management of dynamic transboundary resources, such as water, has historically been one of the most challenging aspects of environmental governance. Even when and where water has been recognised as a commonly held resource under law, equitable access and the management of transboundary impacts to water relies on the premise of having some control over a substance that, by its very nature, defies administrative boundaries. As with other essential transboundary resources, the few often have an increased ability to impact the many. The contemporary management of Scotland's water catchment areas is an interesting case; partly because water law in Scotland has seen little reform since developments that occurred in response to C18th and C19th industry (Robbie, 2015). Technically and practically, catchment management regimes can still cater to defunct historic industries like mills and breweries. One of the legacies of this industrial heritage is that a small number of riparian owners (private individuals whose land abuts or crosses navigable waterways in rural Scotland) now have the responsibility of managing impacts on waterways affecting the environmental benefits of a large number of beneficiaries (see for example Kirby, 1974 and Sargent and Ledger, 1992 on the case of Loch Leven in Scotland).

This legacy presents its own specific set of challenges in the management of catchment areas in rural Scotland. Various approaches have been implemented: government agencies rely on regulatory and advisory approaches to catchment management, but the success of these approaches depends entirely on compliance. The management of catchments must also anticipate changes in temperature and precipitation driven by environmental change. Climate change forecasts for Scotland predict dryer summers and wetter winters (ClimateXChange, 2021). Adaptation to current and future changes in rainfall require new strategies for water redistribution to future-proof management

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strategies and ecosystem services.

This paper explores a complementary approach to catchment management. Research was carried out as part of a broader interdisciplinary research project to develop a tilting weir for the Lunan Water catchment area in Angus, Scotland. The weir is designed to provide three types of ecosystem services. First, it manages sediment deposits and nutrient pollution in wetland areas.[1] Secondly, the weir responds to climate change related increases in winter flooding. It is designed to alleviate winter flooding in the upper catchment and its impact to public infrastructure (i.e. roads) and farmland. Thirdly, the weir responds to climate change related decreases in summer rainfall, delivering improved summer water availability for irrigation in the lower catchment.

To ensure long term local governance of water levels, in particular beyond the length of the scientific project, it was proposed for the tilting weir management to be paid for through a local payment for ecosystem services (PES) scheme. This paper therefore aims to expose and reflect on the challenges encountered in the investigation of the appropriate institutional setting for such a scheme to be implemented. Indeed, the provision of ecosystem services through the envisaged scheme is complicated by the current management of water levels at this particular site. First, a small number of riparian owners control access to historical structures controlling water levels. Secondly, the participation of riparian owners in the scheme is impeded by a lack of legal clarity regarding current and future rights and obligations under such a scheme. This paper sets out the proposed PES scheme, exploring key obstacles arising from the interplay between environmental change, ecosystem services, and adaptive solutions. A PES scheme would allow active water management and the delivery of multiple objectives. Yet, our research findings show that the establishment of mechanisms for governing the PES scheme are difficult to identify, within a catchment that still functions to serve an obsolete industrial heritage, and where those functions are obscured in part by opaque legal rights and responsibilities. The suggestion of a hard-engineered scheme also faces opposition, where policy positions in the Water Framework Directive (WFD) that encourage natural flood management (NFM) have informed public opinion of catchment management best practice. While there may be a preference for NFM among some participants, qualitative data also shows that NFM is rationalised by some participants as synonymous with historic hard engineered industrial heritage. So too, practices such as dredging are seen as complimentary to NFM, despite these practices being in direct contradiction to NFM principles. This complex set of opposing positions and interests combine to create an interesting set of problems.

The paper has two main aims that inform international efforts to implement PES schemes for water catchment management. The first is to draw attention to certain characteristics of complexity that manifest as obstacles to PES implementation. While every catchment is different, the characteristics of complexity can be shared. In this case study, conservation-led catchment management is made complex by increased flood and drought events interacting with industrial heritage, law, power asymmetries, and a diverse range of environmental values. We contextualise the proposed PES scheme through analysis of these characteristics to contribute to the call for more work on power asymmetry, "*the recognition of multiple relational values around human-nature interactions in PES*" and "*the need for greater social contextualization in future PES research*" (Kolinjivadi et al., 2023, p. 8.). The second is to consider how these characteristics intersect with environmental change. An increase in flood and drought events present real and urgent problems for catchments in many parts of the worlds. In this case study, the characteristics of complexity – in particular conflicting environmental values - work to obstruct governance efforts, illustrating how opposing values and aims between conservation on the one hand and adaptation on the other can work to this end.

The next section situates the scheme proposed for local water management in the Lunan catchment within PES approaches. Section 3 gives an overview of the case study. Section 4 discusses our methodological approach. Section 5 sets out the results which are then discussed in Section 6 to scrutinise the characteristics of local support from the three main participants groups (i.e. farmers, residents and other stakeholders) to assess the advantages and barriers to PES schemes for local water management, and to draw general lessons on the PES concept, its design, and implementation.

2. Conceptualising a local scheme for water management

One of the aims of this study was to propose a viable governance approach for the local community to be able to manage water levels for multiple benefits in the long term, after the end of the scientific project. This section details how the funding mechanism for the new water levels management interventions on the Lunan catchment was conceptualised as a local payment for ecosystem services scheme, and how the choice of the intermediary appeared as a key aspect to be investigated.

The proposed scheme uses an incentive-based approach, payments for ecosystem services (PES), that shows distinct advantages in the management of multiple benefits at the catchment scale. PES schemes are based on voluntary payment arrangements between individual beneficiaries and service providers to establish or increase the supply of Ecosystem Services (ES). In a situation where the ES' contribution to beneficiaries' welfare is higher than the cost for providers to produce these ES, then a local arrangement can be found where the beneficiaries pay the providers, generating a win-win situation across its participants (Wunder, 2013).

PES schemes have been envisaged as an efficient solution to ensure the provision of local public goods, such as water (Matzdorf et al., 2014), and have been successfully implemented in the context of water management in the Vittel water catchment area in France (Déprés, Mzoughi, 2008) and then in several catchment areas in Southwest England under the "Upstream thinking" scheme (Matzdorf et al., 2014), amongst other examples. These schemes have the potential to increase both suppliers' and beneficiaries' welfare, by increasing the availability of ES for beneficiaries, whilst at least compensating the providers of such services. Implemented at a catchment scale, they have the potential to better adjust the provision of multiple benefits to local needs.

One precondition to the implementation of PES schemes is that the seller has *"clear and secure rights"* to change environmental management in a way that will produce the required ecosystem services (Swallow, Menzein-Dick, 2009, p. 252). In the absence of such rights, or when the owner of these rights cannot endorse the role of supplier, one solution proposed in this paper would be the intervention of an intermediary, taking responsibility for the supply of ecosystem services by managing water levels instead of the riparian owners. The landowners would provide permission to the provider to enter their land but would not bear this responsibility themselves, as shown in Fig. 1.

With the introduction of such an intermediary, a funding scheme for water levels management in the Lunan catchment would resemble PES approaches conceptualised in Sommerville, Jones (2009), p.2): "*approaches that aim to (1) transfer positive incentives to environmental service providers that are (2) conditional on the provision of the services, where successful implementation is based on a consideration of (1) additionality and (2) varying institutional contexts*". The "Working for Water" programme in South Africa is an example of PES scheme where the

[1] Lateral oligotrophic and mesotrophic wetlands are vulnerable to infilling and eutrophication by flows of sediment and nutrients from upstream (Werner and Zedler (2002); Rojas and Zedler (2015); Leisti et al. (2016). The value of a catchment systems engineering approach to conservation and management of river systems and their associated wetlands is recognised (Wilkinson et al., 2014). Hydraulic structures and their management can play a role in such management (Baumgartner et al., 2020). Tilting weirs that adapt according to forecast or actual hydraulic conditions have been used as part of management strategies (Wang et al., 2023).

Fig. 1. Potential role of an intermediary for the implementation of a local PES scheme base on water levels management.

land-managers are not the ones receiving the payment (Turpie et al., 2008). In this programme, former unemployed individuals are paid to remove invasive species for improved water management at the catchment scale. Wunder et al. (2008) describe this scheme as a PES-like scheme: *"the WfW case is atypical for PES, and resembles more the generic family of environmental food-for-work programs (*Holden et al., 2006*)"*. However, Turpie et al. (2008) argue that although *"this form of transfer payment does not constitute the creation of a market for the provision of ecosystem goods and services in the strict sense, it does constitute a payment for the service delivery." (p.792)*.

Beyond the need for an intermediary acting as supplier of ecosystem services, large numbers of beneficiaries, as are present in broader water catchment areas, and the multiplicity of ecosystem services, also justify an intermediary body (for example, a division of government, or a non-government organisation) to step up and coordinate the demand for ecosystem services. *"External intermediaries and facilitators can play important roles in creating trust between actors that […] do not usually interact*" (Wunder, 2013, p.233). Markets for ecosystem services are growing, and private sector buyers of ecosystem services are looking for "aggregators" able to facilitate transactions between ecosystem services market actors (Green Finance Institute, 2023). This increasingly hybrid nature of PES schemes in which private funders, non-profit organisations and the public sector cooperate to fund changes in land management practices (Ezzine-de-Blas et al., 2016), delivering a range of ecosystem services that will jointly benefit public and private sectors, makes the role of intermediaries between service providers and beneficiaries even more salient.

The creation of adequate institutions, the interplay of PES schemes with existing institutions, formal or informal, and the distribution of benefits generated by the scheme can prove to be a divisive issue that undermines implementation, and have become focal points of the PES literature (Corbera et al., 2019; Shapiro-Garza, 2019; Everard et al., 2020). When the alternative water levels management strategy was first proposed, no existing institution was naturally identified to take the role of the intermediary and be responsible for the provision of ecosystem services in the catchment. One of the steps in the design of the Lunan Water scheme was, therefore, to identify who the best intermediary would be to act as the service provider. Hence, one key focus of the study has been to identify the right intermediary. This question, alongside general support for the proposed scheme, is investigated through a mixed method approach. A contingent valuation survey and a series of interviews with local residents, farmers, and stakeholders investigated the legacies of environmental management in the Lunan, and the significance of these in informing and facilitating the implementation of new water level management strategies under a PES scheme approach.

3. Case study overview

The Lunan Water catchment area is located between Montrose and Forfar in the county of Angus, Eastern Scotland. The Lunan Water drains an intensively farmed mixed arable catchment of 134 km^2 from its source near Forfar to the Lunan Bay (Fig. 2). The Lunan Water river course has been modified and is now a complex hydrological system that includes lades[2] and historical water levels management structures used for milling purposes in the 17th century. The upper catchment includes two lochs, Rescobie and Balgavies lochs, both being part of a Site of Special Scientific Interest (SSSI), and several wetlands such as Fonah bog which have valuable biodiversity and provide ecosystems services in improving water quality. The whole of the Lunan catchment area is nontidal and therefore subject to private ownership.[3] This is further complicated at the field site by the presence of engineered structures on the riverbed, remaining from mills of the 18th and 19th centuries, that continue to manipulate the flow water (Vinten et al., 2021, Figure 11).

There are a number of water management issues in the Lunan Water catchment at present. Some research participants have experienced flooding problems in the winter, especially in the upper catchment. The lower catchment experiences water shortages in the summer, contributed to by water abstraction. Farmers are granted abstraction licences from the Scottish Environmental Protection Agency (SEPA), the environmental regulator and abstraction licensing body. The water is mostly used for potato cultivation. Records show 50 farmers abstracting water from the catchment over the summer months (Vinten et al., 2017). Additionally, nutrient pollution from farming practices is impacting water quality and threatening plants and wildlife in valuable wetland habitats at the outskirts of the lochs (Dunn et al., 2014; Gunm et al., 2017). Addressing these issues formed the focus of a scientific research project that proposes installing two devices: a flow restrictor and a tilting weir. The research provided evidence that both devices would allow better control over water levels and prevent rivers and lochs upstream from overflowing during winter storms (Vinten et al., 2019). These gates could also be used to divert water away from sensitive downstream wetland habitats during autumn when the water flowing from the lochs is often of lower quality, by redirecting the outflow from the lochs through channels that avoid the wetlands. The diversion of this sediment downstream is not likely to have a major impact downstream as the deep, man-made, in-line impoundment, called Guthrie loch, 1 km downstream is capable of long-term attenuation of this sediment by retention (May and Vinten, 2018).

Finally, this system could help store water in late spring which could then be released in late summer if water becomes scarce, thereby increasing the availability of water for use by farmers and other users further downstream. The sites the devices would be installed on were both in private ownership, on a riverbed shared between two riparian owners (i.e. that section of the river forms the border of two adjoining properties). Recently a live forecasting model of water levels as a function of recent rainfall and management choices has been implemented to assist potential active management (Vinten et al., 2021).

[2] A lade is the channel (sluice/race) conducting water to or from a water wheel.

[3] Although the alveus (riverbed) of navigable tidal rivers reverted to the Crown in 1887, the alveus of non-tidal rivers remains private property in Scotland. Ownership of the alveus is invested with certain responsibilities not to impede access to the common resource, whether directly, or by interfering with the flow of water in a way that could negatively affect those users downstream (Robbie, 2015).

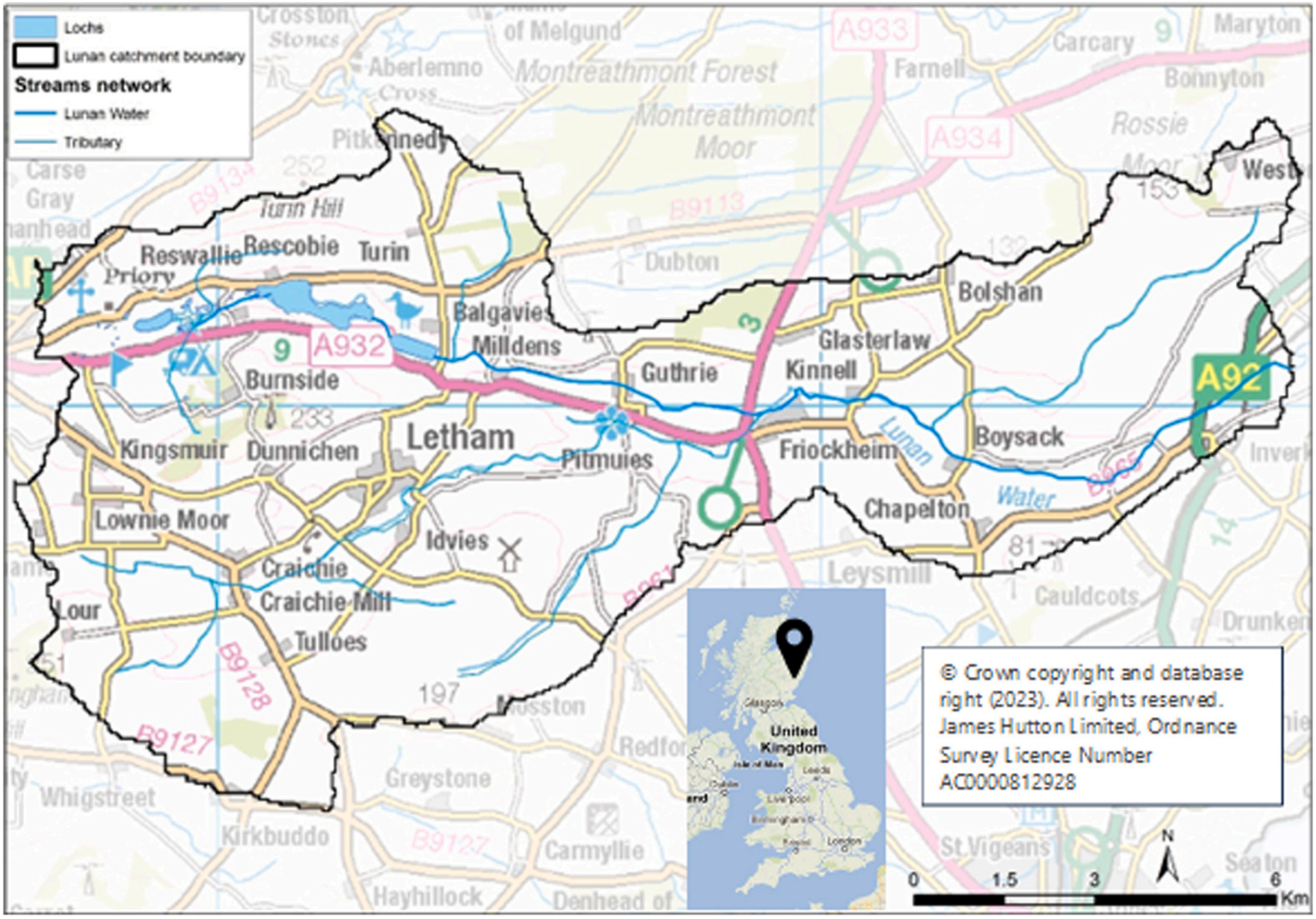

Fig. 2. Map of the Lunan Water catchment (credits: map created by [*removed for review*]).

The proposed intervention (installation of the two devices) was developed by researchers in conjunction with the Lunan Water catchment management group. The group was established in July 2016 and includes representatives of the local authority, governmental and non-governmental environmental organisations, representatives of farming and fishing, other relevant local organisations and other academics. Members of the group represent different publics and interests: the local council has responsibility for flood management; the Scottish Environmental Protection Agency for water quality and abstraction management; the Scottish Wildlife Trust owns and manages Balgavies Loch; Scottish National Heritage is a statutory consultee on Sites of Special Scientific Interest including Rescobie loch and Balgavies loch. The terms of reference of the group were to work collaboratively to improve water management in the Lunan Water catchment. Hydrology experts leading the project have developed models that support the conclusion that the proposed interventions in the catchment area would lead to a better conservation of biodiversity, reduced flood risks and reduced risks of low flows in the summer (Vinten et al., 2021). The new system would benefit residents of the catchment as well as farmers who have abstraction licenses on the lower part of the catchment. Residents and farmers of the catchment, as beneficiaries of the ecosystem services, are therefore the population of interest for the survey implemented during the project.

The proposal for a tilting weir was presented to the Lunan Water catchment group members at the first meeting in 2016 and discussed at subsequent meetings (Vinten et al., 2019). The proposal was set aside in November 2017 because of difficulties in progressing the scheme which will be explored below. The most recent catchment management meetings have therefore led to an agreement on a focus on the promotion of the wetland conservation benefits of the scheme through the reinstatement of a historical water levels management structure which would continue to be managed passively as with the status quo, instead of the installation of a new tilting weir which would require more active management.

The Scottish Environment Protection Agency governs activities that may damage the water environment through pollution or structural changes. Certain good management practices are covered by general binding rules that need to be complied with but do not require authorisation from SEPA (2017). More invasive activities require registration with SEPA or a licence, which requires a named person, company or partnership to be responsible for the activities. “Impounding works” relate to the managing of water levels on a dam, weir or raised loch or the construction or alteration of these. “Engineering works” cover all other works on inland surface water or wetlands that are likely to have a significant impact on the water environment. Authorisation is not required for the removal of vegetation or debris, rubbish and fallen trees from water bodies. The requirement for a registration or licence for dredging depends on the width of the river and whether it has been previously straightened. Authorisation is required for any dredging in a river greater than 1 m in width.

4. A mixed method approach

The data collection used a ‘connected’ mixed-method approach, combining a quantitative questionnaire and qualitative interviews, whereby analysis of the first data stage was further developed in the

second data phase (Creswell, 2012). The overall approach investigates local contributions to, preferences within, and support for the development of a new water management scheme in the Lunan catchment. This paper aims to answer: how are PES schemes perceived by research participants, and how do these perceptions challenge the implementation of PES schemes for water management? Of particular interest is the identification of the right institution to take on the role of intermediary on the PES governance structure. Ethical approval for the questionnaire and interviews was obtained from [*removed for review*] Research Ethics Committee.

4.1. Quantitative methods

Quantitative research design drew from interviews carried out in 2014 that identified the key issues perceived in the catchment (Shortall et al., 2017). This material, as well as discussions in the water catchment management groups and pilot interviews with local farmers supported the design of the quantitative questionnaire. The questionnaire is based on a contingent valuation approach, which measures how much respondents value the benefits (i.e. the changes in ecosystem services) that would be provided through its implementation. It is structured in 3 parts, including a mix of closed and open-ended questions. The first part includes questions related to the current use of the Lunan Water catchment natural environment and perception of its present condition. In the second part of the questionnaire, respondents were asked to state their willingness to pay (WTP) under three different governance scenarios in which the intermediary responsible for the water levels management under the PES scheme differs. The 3 options presented to respondents were the following:

1. Management by local council with funding levied through an increase in the household council tax over 10 years (values ranging from 0 to £40 annually),
2. Management by local stakeholders, in the form of a Community Interest Company, with funding raised through a one-off investment over 10 years in shares ranging in value from £ 0 to £ 400 (once for 10 years),
3. Management by a charity organisation with funding raised from donations in the form of an annual membership over 10 years, with values ranging from £ 0 to £ 40 annually.

The WTP values were collected in a multiple-choice question presenting 10 values of WTP within the ranges defined above for each option. The values were presented in a random order. Participants were also offered the option to enter a value above the higher band of the proposed interval in an open format.

The third and last part of the questionnaire contained questions aimed at further understanding the stated WTP and at collecting the main socio-demographic characteristics of respondents.

As explained in Section 3, the population of interest are the beneficiaries of the ecosystem services that could be provided through the new water levels management system: catchment residents and farmers. The questionnaire was sent through the post to 60 farmers and distributed to a random selection of 200 residents from the Lunan Water catchment.[4] They were provided with a paper version of the questionnaire and a pre-paid return envelope. Participants were also given the option to access an online version of the questionnaire developed on LimeSurvey, with a link provided on the first page of the paper version of the questionnaire. Additionally, 5000 leaflets were distributed in the local area to advertise the online version of the questionnaire.

12 farmers and 61 residents responded to the contingent valuation questionnaire, for a total of 73 responses, including 39 from the postal survey and 34 from the internet survey. 62 of the 73 respondents live on the catchment while the 11 remaining ones live in the broader council area of Angus.

Table 1 shows that men over 55 are over-represented in our sample when compared to the average age and gender balance in Angus. This apparent bias may be partially explained where household level responses fail to include the socio-demographic of all respondents. Farmers who responded to the contingent valuation questionnaire are a majority of mixed farmers, though the sample also includes 1 specialist livestock farmer and 1 specialist cereal farmer. 10 out of 12 grow potatoes on their farm, which is occasionally irrigated in the catchment area and could therefore benefit from an increased availability of water in summer.

The data collected through the survey were used to identify the range of perspectives on water management in the Lunan catchment. A hierarchical cluster analysis was performed to identify groups of respondents with similar attitudes towards the project. The hierarchical clustering identifies groups of homogeneous observations based on a selected subset of variables. These variables were selected to include as much relevant information, while preserving as many observations as possible, as the full observation is dropped when a missing value is present for at least 1 variable. The agglomeration criteria used is the Ward's linkage method based on Euclidian distances. All statistical analysis of the questionnaire data was implemented in Stata 14.

4.2. Qualitative methods

17 qualitative interviews were carried out in person between September 2017 and December 2017. Prospective interviewees were sought across three groups representing the beneficiaries of the scheme as well as existing institutions currently in charge of environmental management in the catchment area: farmers (3), residents (7) and stakeholders (7 interviews involving 8 stakeholders[5]). Purposive sampling was used to select farmers and key stakeholders (Guest et al., 2006). Purposive sampling means targeting a particular group of individuals because of their relevance to the research questions. Individuals from the small number of key stakeholder organisations relevant to the project were interviewed. The 3 farmers interviewed also had a direct stake in the project because of the location of their land. Thus, the views expressed by the 3 farmers interviewed are not taking as representative of the views of farmers in the area more widely. A different sampling strategy was used in relation to residents as there were no equivalent individuals who acted as "key informants" among the resident group. Rather residents who expressed differing views in the

Table 1
Descriptive statistics of sample: age and gender. *Note: 1 observation is missing for age, and 7 are missing for gender.*

Age	Freq.	%	Gender	Freq.	%
25 – 35	1	1.4%	Male	49	74.2%
36 – 45	5	6.9%	Female	17	25.8%
46 – 55	10	13.9%	**Total**	**66**	
56 – 65	29	40.3%			
Over 65	27	37.5%			
Total	**72**				

[4] Farmers, and their postal addresses, were identified using Google and Yell searches. The survey was sent to all identified farmers whose main address was located within the catchment area. The survey (questionnaire with pre-paid return envelope) was delivered to residents by a hired distributor who was instructed to distribute them at random in the letterbox of households within the catchment areas. The same distributor was in charge of delivering the 5000 leaflets in letterboxes within the catchment area.

[5] One of the interviews included 2 stakeholders representing the same institution.

survey were invited to take part in the interview to expand on their positions and ensure that we understood and fully captured residents' perspectives. Resident interviewees were selected from a group that volunteered via the survey questionnaire. Other participants were approached individually. Interviews averaged 1 h in length and followed a semi-structured guide designed to investigate; (a) environmental impacts; (b) current water management regimes; and (c) the proposed tilting weir and penning structure scheme for Balgavies loch. Interview discussion covered a number of topics in detail including flooding, nature conservation, land and water use, natural water management, and support for the proposed tilting weir scheme. The interviews were audio recorded and transcribed.

Transcripts were coded and analysed using the qualitative analysis software NVivo 12 (QSR International). Data was coded thematically resulting in three main nodes that reflect the structure of the interview guide: a) environmental impacts resulting from flood and drought, b) formal and informal management practices, and c) WTP for the proposed tilting weir scheme. Aggregate coding of "child nodes" (i.e. subcategories) produced a second set of themes: (a) Rights and responsibilities over water; (b) perceptions of expert scientific knowledge and practice; and (c) concepts of 'nature' and 'natural' systems. Word search queries were then run through NVivo against all coded files to cross-check thematic coding.

Coded data were analysed using a tripartite approach. First, analytic queries were run through NVivo. These included quantitative queries (e.g. queries run on combinations of nodes to investigate distribution of data under particular themes), and queries to compare attribute values. Secondly, data under each node were analysed using comparative methods (e.g. comparing the data of participant groups) and hermeneutic approaches (e.g. close reading). Lastly, the secondary themes identified were analysed using critical discourse analysis, specifically interdiscursive analysis (Fairclough et al., 2011), to consider how coded themes are defined by particular discourses (e.g. the repetition of cultural references). The quotes in which respondents may be identifiable and used in this publication have been resubmitted to interviewees to confirm their consent and to offer them a chance to correct. One respondent has asked to make grammatical correction to their quote, while another has provided clarifications and complements, to update their quote.

The main benefit of using a mixed method approach to analysing interview data is in the identification of controversies (arising from conflicting positions) that explicate the quantitative results. These controversies arise as themes that are secondary to those structuring the interview guide. First, quantitative analysis proceeded qualitative data collection. Secondly, the combination of (a) running quantitative queries in NVivo (e.g. word frequency), (b) close reading, and (c) discourse analysis of node categories in NVivo (in that order) facilitated the identification of conflicting positions in the data. We suggest this was successful because the combination of methodological approaches used produced a qualitative data analysis process that was both deductive, where data analysis follows a process of evidence-based reasoning (in this case using quantitative data as a starting point for asking questions), but also productive, where quantitative data is positioned as a productive agent from which qualitative analysis can expand.

5. Results

5.1. An existing demand for ecosystem services

The implementation of a tilting weir to better manage water levels would support the provision of three main ecosystem services: first, flood alleviation in the upper part of the catchment; secondly, improvements in the quality of water flowing into biodiversity-rich wetland thereby supporting these ecosystems; and finally, the provision of water for irrigation in the lower catchment during dry months. The data collected through the contingent valuation survey is analysed to understand whether there is a demand for the provision of these services amongst the local catchment residents and farmers by measuring their willingness to pay.

Respondents' answers to the first part of the questionnaire, related to the current use and perception of the environmental state of the Lunan Water catchment, show a potential demand for flood management and biodiversity conservation, while the potential demand for increased availability of water for irrigation appears less clearly. 8 of the 12 farmers reported having experienced flooding on their property, mostly affecting their fields. The incidence of flooding is less important amongst residents with 18 of the 61 residents (about 30%) reporting having experienced flooding in the Lunan Water catchment area. These reports related mostly to flooding on roads leading to road closure, especially along Rescobie Loch. Residents also report flooding on paths, gardens and driveways, and concern that the houses might also be impacted at some point leading to financial burden. Some long-term residents report noticing the rise in the water levels of Rescobie Loch. More than half of the respondents stated being concerned (34) or very concerned (6) by this issue. Other residents, who are not concerned about flooding, state that they have not noticed major flooding events on the catchment.[6] The Lochs are also a key recreational site for walking and wildlife observation with 48 respondents (69%) visiting Rescobie Loch or Balgavies Loch nature reserve on a regular basis. Finally, while 8 of the 12 farmers abstract water from sources within the catchment area during dryer years, only 2 abstract water on an annual basis. Most farmers expressed low levels of concern regarding restrictions on water abstraction despite 5 of the 12 farmers being located in the lower catchment.[7] Yet, this result may be influenced by farmers who have never experienced restrictions. Farmers who were concerned about restrictions highlight water supply for irrigation, the impact on profitability, and the potential adverse impact of low flows on landscape and wildlife. Perceptions of the ecosystem services provided by the new water levels management scheme, flood control, biodiversity preservation and availability of water for irrigation are shown in respondents' preferences for water management: 44% of respondents state that they would prefer the water management strategy to give a top priority to flood control and 26% to biodiversity preservation in wetlands while a lower priority is given to abstraction issues.

Overall, the proposal for the tilting weir project received support from close to 70% of respondents (Fig. 3). There were clear disparities between residents and farmers (Fig. 3). Farmer respondents appeared particularly divided on whether the project should be implemented. Opponents of the weir included some respondents that would not benefit from the project, and others proposing that alternatives such as dredging or natural flood management would achieve the same aims more efficiently. Most supporters of the project value its capacity to reduce flooding issues and its role in wetlands conservation. There was particularly strong support for the 'storing' of winter flood waters to mitigate low-flows in the summer, seen as a win-win situation.

In order to quantify the level of support for the project, a willingness to pay (WTP) approach was used through a contingent valuation. The average WTP ($n = 183$), is of £ 6.34 per year for 10 years (95% confidence interval[8]: [£4.95; £7.74]).

About 50% of responses (92 out of 183) are null WTP, showing that the apparent support for the project - 70% of respondents stating that the weir project should 'probably' or 'definitely' be implemented (Fig. 3) -

[6] Since data collection, flooding has increased in the region and so levels of concern may have changed. There have been increases in heavy winter rainfall and days of heavy rain in winter. An increasing proportion of rainfall has been coming from heavy precipitation events (ClimateXChange, 2017, p.1)

[7] Location of farmers is based on their reported postcode (first half of the postcode), which we use as a proxy for the farm being located in the upper or lower catchment.

[8] Confidence intervals were calculated with bootstrapping, 1000 replications.

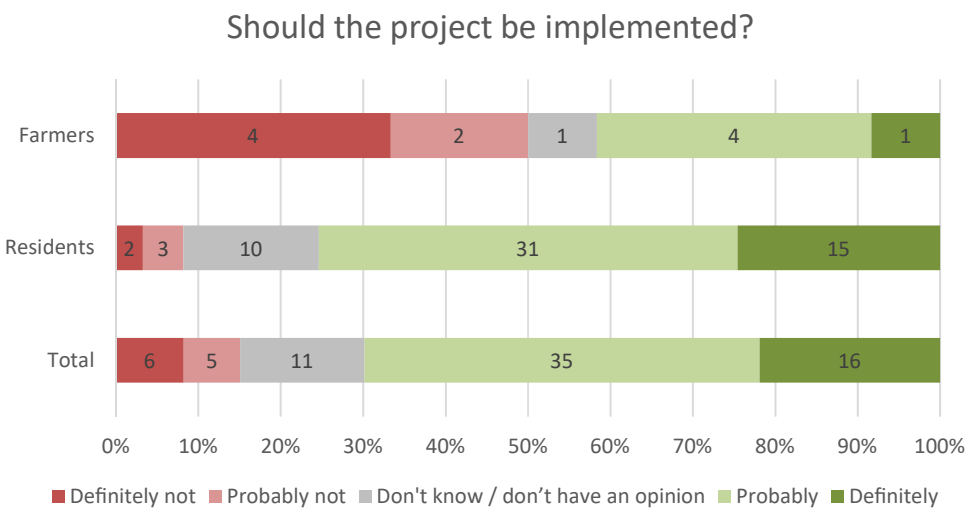

Fig. 3. Farmers, residents and overall support for the project. Data labels included on the chart represent the number of observations.

does not fully translate in expression of WTP. The reasons behind the null WTP (Table 2) provide valuable information on the concerns associated:

1. With the weir infrastructure itself, with about 50% of stated WTP being null due to a perceived absence of need for the project, a belief that the weir will not improve the situation or that it is not a viable option;
2. And with the proposed institutional setting (PES scheme), illustrated by the high level of null WTP that are due to either the lack of confidence that the project will be managed correctly with the proposed intermediaries, a belief that others should fund it and/or a preference for other ways of funding.

A large proportion of the null WTP statements stem from the second point, a lack of support and concerns about the proposed institutional setting, i.e. how the scheme would be either funded or managed rather than the infrastructure itself (Table 2).

In addition, there is concern over the identification of an appropriate intermediary that would undertake the legal responsibility of managing water levels following implementation of a PES scheme. This intermediary would be at the interface between the beneficiaries and the landowners, using beneficiaries' payment to the PES scheme to manage water levels through the tilting weir system and thereby delivering the associated ecosystem services. These may include, but are not limited to, the options suggested in the quantitative questionnaire: a) local council, b) a body of local stakeholders, in the form of a Community Interest Company, and c) a charity organisation. This is addressed separately below.

Table 2
Reasons behind null WTP (several options could be selected).

Reason stated for null WTP	Council	Business	Charity	TOTAL
I cannot afford to pay	2	4	3	9
I don't have confidence that the council/ business/charity will be able to manage	13	14	13	40
I shouldn't be the one paying for it	10	15	11	36
No need for the project	10	9	7	26
Project won't improve situation	6	8	9	23
Project not viable	3	3	2	8
Prefer other mechanism for paying	3	4	1	8
TOTAL	**47**	**57**	**46**	**150**

5.2. The need to identify an intermediary to endorse the role of service provider in a PES scheme approach

5.2.1. Concerns over legal and perceived responsibilities

The tilting weir scheme proposes a hard-engineered solution designed to respond to increased flood and drought, while also delivering multiple benefits. The success of the scheme relies on the identification of an intermediary, but this is complicated by the need for access rights to the site of the proposed weir from a small number of riparian owners. Moreover, while there is good local support for the scheme amongst stakeholders and residents, the scheme faces opposition by farmers on a number of fronts, despite the potential benefits. Qualitative data shows that these concerns mainly relate to the rights and responsibilities of farmer riparian owners to access and manage water, and the interpretation of these rights under the proposed weir scheme. This is further complicated by the question of legal ownership: as the waterways under question are classified as both non-navigable and non-tidal, the alveus, or riverbed, is subject to private property law. In the case that such a waterway forms a boundary between two properties the boundary is drawn at the mid-point of the riverbed which results in there being two riparian owners. Both the historic sluice gates and weirs, and the proposed site of the tilting weir scheme are on such a boundary. Concerns are two-fold: First, there is uncertainty about the legal status of the historic weir and sluice structures that were installed before current legislation was in place. This is pertinent to developing a regime for opening and closing the sluice gates and identifying whose responsibility this should be. Secondly, there are questions concerning who would be legally responsible for any new structure and whether these parties could be brought to account for the catchment hydrology if detrimental effects are connected to its operation.

Riparian owners have, though, taken on responsibilities for water management in so far as these responsibilities are situated or reliant on their land. There is a sense of ownership over these responsibilities and a clear sense of cultural heritage in the continuity of customary practices of water management. These practices have developed around water law, allied to legal principles such as not to obstruct reasonable access to water. Customary practice relies on traditional dredging and clearing methods that are seen as a viable strategy for addressing the increase in drought and flood events. Yet, even in these historically embedded practices, legal responsibilities remain unclear.

The lack of legal clarity compels riparian owners to anticipate any negative consequences from the installation of the proposed tilting weir scheme. One owner stated that:

> … if the tilting weir is built, it will be perceived that it is on my land and on [the other riparian owner's] land, and so we will be perceived as the owners of it or the controllers. I certainly have no intention of wanting to control it, but that will be the perception, and if there are other unforeseen issues involved to do with the tilting weir, be it working or having other things, it will land back on my head rather than anyone else's, which is a worry to me. No, that's my main worries about it. (Farmer 1)

Farmers also showed concern regarding what effect the scheme would have on their custodial roles. While there are concerns regarding *increased* responsibilities, there are also concerns regarding *reduced* responsibilities. Several participants commented that landowners' and farmers' autonomy in water management had been reduced in recent decades, with landowners having less freedom to clear waterways and carry out other maintenance. Farmer 1 stated that:

> In years gone by, [if farmers] were getting some flooding, they'd go and do a bit of dredging or they'd remove the weeds. I'm going back, I'd say, after the Second World War. They'd just go in, and they didnae [didn't] need to ask anybody. They just went and did it and they looked after it. (Farmer 1)

For some farmers a reduced role in managing water levels undermines a sense of stewardship over the land: "Some boy reclaimed that [land] two hundred years ago and I don't want it to go back to being marsh, to being bog." (Farmer 2) Customary water management practices of dredging and clearing are also trusted. Several participants stated that environmental policies against these practices, and the resultant reduction in responsibility for farmers has resulted in a lack of maintenance directly associated with flood events: "if the river Lunan was flowing naturally [i.e. cleared and dredged], it would never flood. No place would flood. If it was flowing naturally and there were no holdups, it would never flood". (Farmer 2).

Hence, the tilting weir scheme presents the risks associated with legal accountability, while also carrying associations with current policies that have reduced customary roles, replaced traditional methods, and (because of this) are considered less effective. The viability of the titling weir scheme was similarly criticised by another farmer:

> I've always said I wouldn't stand in [the tilting weir scheme's] way if I could see definite benefits from it, and I think the benefits are not proven at all. That's my problem, and that's why, at the moment, I wouldn't give consent for it to go ahead… I can see [the tilting weir] holding water back, but in a big flood situation, I don't get it being able to lower the water level … I've looked through it, but that doesn't seem to stack up, to me.I suspect that the ground [upstream] has always flooded, and if we get any more extreme weather events, it is more likely to flood. It may be that's something that's just going to have to be lived with. (Farmer 3)

5.2.2. The role of an intermediary: towards equitable access

The case for the new weir scheme is based on evidence that environmental benefits in the catchment are not accessed equitably under the current water level management plan. Seasonal flood and drought events are the largest contributors to these inequities which take shape around upstream users and downstream users. Most of the flooding that could be mitigated through the scheme happens in the upper part of the catchment alongside the lochs and affects all local road users. However, upstream users are better positioned for water extraction during droughts. Downstream users, therefore, stand to benefit most from the drought regulation effects of the weir scheme which aims to redistribute water to address these asymmetries. Yet, downstream users also show less willingness to participate in the scheme. When asked about the possibility of farmers paying for irrigation water in the future Farmer 3 replied that:

> [farmers are] annoyed enough about having to pay for their licences at the moment… there is a perception they see [water] as a sort of God-given right – wrongly, in my view – but there is definitely a perception in the agricultural community that they see the water as their God-given gift. If water flows through their land, they should be allowed to suck it out…I actually think they should have to pay for water…I think irrigation water should be metered. That would be my view, and that would not be popular among my big-irrigating neighbours…I think [water is] a commodity…There are plenty of parts of the world where [water] is a…scarce resource, but here there is no perception of it being a scarce resource. (Farmer 3)

The quantitative data shows that the tilting weir scheme has the support of the majority of questionnaire participants (see Fig. 3). Yet it lacks the support of a minority of farmer participants on whose consent and participation the scheme relies. The farmers' main concerns centre around legal rights and responsibilities over both the existing historic structures and the proposed tilting weir scheme. There are also other concerns to do with the effectiveness of new over traditional water management strategies, and the resultant reduction of responsibility for farmers. Thus, the inequity of water access is reinforced by both upstream riparian owners' hesitancy over the scheme for lack of legal clarity and other reasons, as well as downstream users' unwillingness to pay.

There is support across farmer, stakeholder and resident groups for a regulation to be developed that would prevent upstream landowners – for whom there is better water security – acting in their own interests. The participants that support this regulation for its ability to facilitate more equitable access to water also support the proposed weir scheme for its potential to achieve more equitable access for downstream beneficiaries. This evidence strengthens the case to identify an intermediary to act in place of the service provider. This offers a potential solution to what we suggest is the most institutionally complex concern identified – the lack of legal clarity for riparian owners. An intermediary that can claim legal responsibility, even if that responsibility is not clear in law, absolves the riparian owner of any ramifications over the implementation and operation of the weir scheme. Ultimately though, the instatement of an intermediary would facilitate representation of the majority of respondents, who were interested in more equitable access to benefits, but whose support rests on the identity of that intermediary.

5.3. The challenges of identifying the appropriate intermediary

5.3.1. Diverging preferences over three potential intermediaries

In the questionnaire, respondents were asked to state their WTP successively under three different governance scenarios. The analysis of the reasons provided for not being willing to pay to support the scheme, in particular the lack of trust towards the proposed managing institution, is particularly important in our setting since we tested several governance scenarios, some of which, as will be discussed in the next section, triggered high rates of rejection.

When survey respondents are asked to rank their preferred management option, the overall preferred option is management by local government, funded through the household council tax (ranked first by 37 out of 62 respondents). The business governance, in the form of a Community Interest Company, is mostly ranked second (by 26 out of 62 respondents), while the charity is the least preferred option for most respondents (ranked third by 33 out of 62 respondents). The project receives the highest support, measured by the average WTP, under the local government scenario which is in line with previous results regarding governance preferences (last column, Annex 1). Surprisingly, the business scenario triggers the least financial support in terms of WTP, when it appears as the second preferred option (last column, Annex 1). This can be explained by the higher number of residents stating that they should not be the ones paying under this scenario. This suggests that respondents feel they must directly benefit from the project

when it is managed by a business, in contrast to support for contributing under the local government and charity scenarios when they do not directly benefit. In order to better characterise these disagreements over governance, we examine the results of the cluster analysis.

Respondents were clustered in 4 groups of homogeneous preferences based on the following:

1. whether they are residents or farmers;
2. their WTP for the project under the 3 alternative governance scenario;
3. the reason provided for a null WTP (lack of confidence in institution, lack of perceived responsibility or lack of support for weir infrastructure itself);
4. their current exposure to and concern about floods;
5. their current use of the wetlands;
6. their preferred environmental priority for water management in the Lunan catchment (wetlands, flood management or abstraction)
7. and their overall stated support for the project.

The sample was divided in as many clusters as possible until groups of 1 were starting to emerge, which led to the identification of 4 groups. 44 respondents had provided values to all these variables, while 29 had missing values for at least 1 of the variables and were not classified. Their characteristics are presented in an additional fifth category. Annex 1 shows the characteristics of each of these groups of respondents,[9] which are summarised in Fig. 4. It is interesting to note that farmers are included in all 4 clusters.

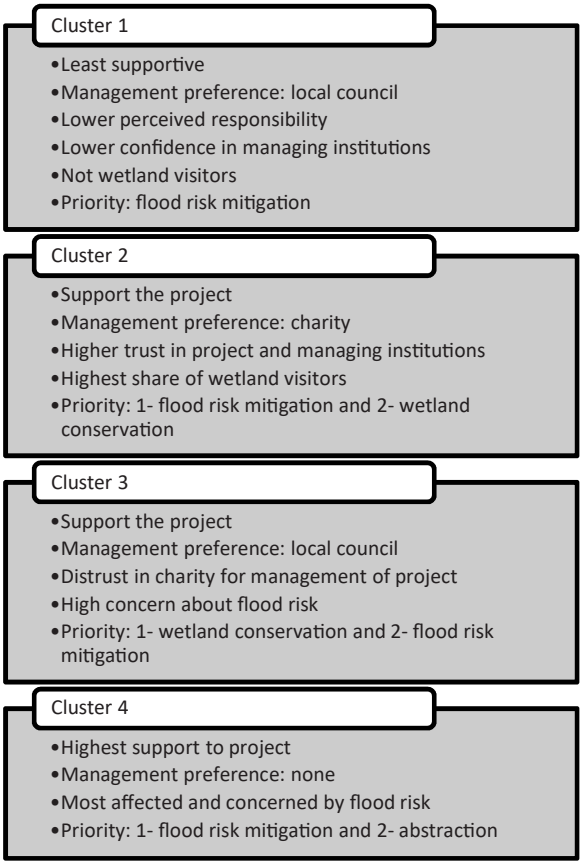

Fig. 4. Summary of cluster characteristics.

The first cluster of respondents can be characterised as being the least supportive of the installation of the weir, with the lowest levels of WTP for any of the governance scenarios. They show a preference for a management of the weir by the council, with close to null WTP for the other 2 scenarios, and the overall highest level of null WTP to support the project, which, as seen in Table 2, is related to a lack of support for the weir infrastructure itself, a lack of perceived individual responsibility and a lack of confidence in the managing institutions. Despite a significant share (about half) of this group having experienced flooding, very few are actually concerned by floods. This group displays the lowest share of individuals visiting the wetlands, compared to the other groups and mostly considers that reducing flood risk should be the priority of such a scheme.

Members of the second cluster are the supporters of the charity management scenario, and supporters of the scheme overall, with low levels of distrust in the project or institutions. This group includes the highest share of visitors to the wetlands, and, after flooding, they would prioritise wetlands conservation within the objectives of the schemes over abstraction.

The third cluster can be characterised as a group supporting the project, with a preference for management by the local council. They display a particular distrust in the ability of a charity to manage such a scheme. Despite being amongst the least exposed to flooding in the past, they are amongst the most concerned about it.

The fourth cluster includes those individuals who are supporters of the project but indifferent over the management scenario. They are the most exposed to flooding as well as the most concerned by this issue. This is the only group that gives abstraction the second rank in the ranking of priorities for the project objectives, after flooding and before wetlands protection.

The preferred intermediary (council, charity, community-owned-company) therefore seems to be associated with different preferences for environmental benefits. As further explained in the next section, identifying a suitable intermediary in the context of the Lunan catchment might be compromised by the aim to provide multiple benefits from a single PES scheme, when these environmental objectives are under the responsibility of different institutions.

5.3.2. The challenges of identifying the appropriate intermediary when aiming for multiple benefits

One of the motivations for the design of the scheme was to achieve multiple benefits simultaneously for multiple groups. This widened the number of interested parties who could potentially have a stake in the scheme and take responsibility for governance. However, with multiple benefits, there was also a perception of multiple risks. There was the ever-present threat that some positive outcomes could be affected at the expense of others. The scheme was not interpreted as a win-win-win outcome for flood management, provision of water for irrigation, and improvement of water quality by many stakeholders:

> My concern is that any solution doesn't raise or lower the level of the loch too much because there's some quite important aquatic and emergent plants in the loch which are doing okay at present. If we drastically change the level, that could affect these plants. That's an entirely selfish point of view. I wholly appreciate there are other factors, i.e. homes getting flooded, farmers trying to run a business etc. From our point of view large fluctuations in the water levels in the loch would be of concern. (Stakeholder 6)

The potential for benefits to conflict led to concerns about how governance was to be enacted once the research institute relinquished control and whose interests would prevail:

> Clearly there are many different stakeholders who have an interest in the project and how, if it goes ahead, any water management structures would be managed in the future. Our role is to assess any

[9] Note that those respondents who were not classified because of missing values have similar characteristics to the overall sample in average.

> potential effects on the condition of the designated sites. In order to do that we would need to know not only the proposed water levels but also what the proposed management and governance structures would be. For example: what will the governance structure be (to reflect the interests of the various stakeholders), who will manage the water control structures, who will monitor the water levels (in the loch, water courses and key habitats of the designated sites), what will be the frequency of monitoring and the mechanisms for instigating a change in water levels in response to monitoring results. (Stakeholder 5)

As well as multiple, potentially competing outcomes creating risks for those not in control of the scheme, it was also seen to create problems for any organisation or group taking control of the scheme. There was not seen to be any organisation without a vested interest which would leave them open to complaints.

> I think it's a very difficult one. Because I think whoever takes it on is going to get complaints from somebody. I think it has to almost be an independent body so that makes it very difficult, even the council and SEPA are going to be seen as not entirely without their own agenda. So, I don't know how – that's one big stumbling block: how are you going to manage it? (Stakeholder 6).

Several groups saw potential risks in the project, and while there were potential benefits it was also commented that benefits might not be enough in any one area for any one group to champion it:

> I think it's positive, it ticks the multi-benefit approach box. I think it has the potential to improve the flooding situation. I don't think that's the biggest aspect of it. […] I think what it is, is the actual outputs I think are maybe not going to be significant enough in any area. (Stakeholder 4).

Ongoing governance and management of water resources was seen a challenge in comparison to short term capital investment because of fewer resources, capacity, and a precedent for the former.

> …it's far harder to do that when it's an engagement involvement situation with no…direct outputs in the shorter term than it is if you are saying, 'right, let's build a wall here or put pumps in here'. (Stakeholder 4).

Interestingly, while natural water management solutions were framed as removing the need for ongoing and potentially difficult governance processes, the same was true of one-off capital investment that did not require on-going decision making and management. Thus, the engineered solution not requiring ongoing scientifically competent management was not championed by those favouring stand-alone engineered solutions.

There is also no precedent for a governing body acting as intermediary for an engineered structure on private land:

> I can't think of a situation where we would manage structures on anybody else's land, I'd have to have a think about that actually. We don't tend to manage structures that would control water, as such. (Stakeholder 4).

An organisation actively making decisions about changes to the level of the tilting weir on the land of private individual was seen as a departure from existing practice. A lack of precedence made implementing the scheme more difficult.

6. Discussion: what lessons can be learned?

6.1. A lack of clarity surrounding water rights and responsibilities

The first lesson that can be drawn from this study is that the lack of clarity surrounding water rights and responsibilities may make PES schemes providing a water levels related service difficult to implement. The Lunan Water tilting weir scheme proposed managing public water that runs over private land in order to address a number of water management concerns. While riparian owners currently have legal control over water levels management, our research shows that the perception of risks and responsibilities associated with this role affected their willingness to endorse an intermediary to manage the proposed weir and PES scheme. This is largely because of concerns over who would have ongoing responsibility for water level management. Water rights and legal responsibilities in Scotland are by no means straightforward. They are antiquated: the most recent period of legal developments happened in response to water uses made by C19th industries, which have long since fallen out of production. Due to this in part, private water rights are not well understood, nor are they typically enforced (Robbie, 2015). In the development of the scheme, it was recognised that various rights and responsibilities complicated the implementation of the scheme. It was for this reason that the step was taken to investigate the potential transfer of these responsibilities to an intermediary. In the Lunan, this transfer of rights and responsibilities from the 2 riparian owners to the intermediary (as conceived in Fig. 1) has been problematic. As stated by Vatn (2010), the coordination between suppliers and beneficiaries in a PES scheme relies on the "distribution of rights" and existence of rules. As illustrated in the interviews, however, formal and informal rights and duties are unclear in the Lunan Water catchment. This has been contributed to by the naturalisation of historic engineered structures that has led to the perception that riparian owners are not responsible, *or not being held responsible,* for contributing to flood events.

Clearly defined tenure has been found to be a key pre-condition to the establishment of PES schemes in the literature (Wunder, 2013). While property rights over land are clearly established in the Lunan case study, our study shows that the perceptions and recognition of rights and responsibility over environmental management are equally important, which can be particularly problematic in the case of water-related ecosystems. Other contexts have faced similar challenges: Rakotomahazo et al. (2023) identify mangroves in Madagascar as such an ecosystem. Intertidal areas such as mangrove forests have unclear legal status and in this case responsibility for their management is fragmented between a number of institutions, making conservation through PES schemes difficult.

6.2. Aiming for multiple benefits might lead to a lack of leadership?

The literature calls for the need for stakeholders and publics to be involved in defining problems as well as implementing solutions (Lankford et al., 2004; Waterton et al., 2015) and participation is seen as key to PES implementation (Matzdorf et al., 2014). The Lunan Water scheme involved participatory elements in its design, which was discussed and amended through consultation with the Lunan Water catchment management group. It also proposed ongoing participatory management through a governing body. Yet, while the Lunan weir proposal was supported by approximately 50% of stakeholders, it was unsuccessful in gaining critical support from key farmer stakeholders. This is consistent with findings elsewhere. Economist Sven Wunder notes that:

> Among watershed users, many PES implementers worldwide have noticed that irrigating farmers are seldom willing to make PES payments even when they are relatively wealthy, are the volume-wise largest water users, and would have a clear interest in protecting watershed services they heavily rely on. This lack of payment culture can be related to perceived historical water rights and customary "free" services, to insufficient institutional depth in user organisation […], or to an expectation to be able to free ride on other water users' actions. (Wunder 2013, p 233)

The Lunan case reflects Wunder's position: there is a very low willingness to pay amongst the irrigating farmers surveyed.

The study illustrates many challenges to the proposed scheme, which could be partially explained by the project's pursuit of multiple environmental benefits under a single scheme. These included improvement in water quality, reduction of flooding, and continued provision of water for abstraction. The questionnaire results show that, whilst most respondents perceived flooding and biodiversity conservation as important goals, the demand for increased water availability for abstraction was quite low. The interviews showed, however, that the provision of multiple benefits through the scheme was seen as potentially inequitable where conflicting benefits resulted in the prioritisation of some benefits over others. The survey showed the existence of clusters with different environmental preferences and priorities, for example, conservation over flood mitigation. The potential difficulty in negotiating opposing preferences and priorities might explain the preference for local government to act as the intermediary in the proposed PES scheme: where beneficiaries would be participant in, but not responsible for decision making. Supporting this, analysis of WTP in the contingent valuation section of the questionnaire shows that charity and community owned business intermediaries that offered the greatest community engagement raised the most doubts. Aiming for multiple benefits might render community management more difficult as it leads to an increased risk of disagreement and/or unsatisfactory compromise. Relatedly, as benefits were distributed across several environmental objectives, and because of the disparity in preferences for environmental objectives, no one organisation saw *enough* benefit to champion the scheme and take on the key role of intermediary between providers and beneficiaries of ecosystem services. Critically, this was true of key farming stakeholders whose support was essential.

Lastly, a further challenge lay in the interdisciplinary expertise required for ongoing maintenance of the tilting weir. While the members of the Lunan Water catchment management group all had expertise in their specific area of water management (e.g. water quality, flood management, and wetland conservation) expert management was seen as too problematic for many stakeholders for fear of mismanagement of the delivery of the particular benefits important to individual stakeholders. This speaks to the difficulty of developing leadership of the delivery of multiple interests within resource management (Reed, 2008). As no single institution was willing or able to act as intermediary (environmental management is currently shared between different organisations), the uncertainty over the future governance of the scheme led to a set aside of the scheme in favour of a more passive approach to management. As noted by Vatn (2010) "PES are never established in an institutional vacuum" (p.1247) and finding the appropriate intermediary is key for the implementation of PES schemes (Roberts et al., 2021). The Lunan case study illustrates how the lack of an adequate institution for the role of intermediary can be a key obstacle for the establishment of local PES schemes aiming for multiple benefits in contexts where environmental management is split over multiple independent institutions.

6.3. The provision of ecosystem services may undermine customary practices and stewardship roles

While there have been different governance models developed for water management across Scotland, scientifically engineered strategies are relatively scarce. In our case study, the proposed weir scheme faced resistance at the implementation phase because there is a lack of clarity regarding the legal rights and responsibilities of riparian owners, but also because the scheme challenges the customary practices and stewardship roles of farmers. In our case study, farmers associated the tilting weir scheme through comparison with the natural water management approaches of SEPA and their perceived connection to flood and drought events, despite the distinct difference between hard and soft engineered solutions, and despite there being no evidence of either approach to flood mitigation being the *cause* of flooding. A far more convincing rationale is that the scheme was seen as further reducing the custodial roles of farmers, and challenging traditional methods of water management. Again, this is consistent with findings in Wunder's work (2013), that traditional management (i.e. clearing and dredging) resolves the issue of water level restrictions and makes way for customary "free" services. This finding resonates with literature criticising PES schemes for undermining the traditional conservation practices of indigenous communities in the Global South (e.g. Ravikumar et al., 2023) and emphasises the importance of aligning proposed environmental management practices with established practices of environmental management more generally (Burns, 2019).

In summary, these two positions – the difficulty of developing leadership for the delivery of multiple benefits, and the perceived disconnect between traditional and expert engineered solutions for water management - although held by a minority of participants were critical to the rejection of the scheme. This points to an imbalance of power relations in the catchment, where the provision of ecosystem services can in effect be vetoed by a relatively small number of private owners. It also points to a controversy at the heart of catchment management between traditional and scientific management. As the case for scientific intervention grows under scenarios of environmental change, local consultation does not guarantee a solution: despite the naturalisation of historical hard-engineering in the catchment, there is a strong preference for traditional methods such as clearing and dredging or for soft-engineered solutions (such as natural flood management).

7. Conclusion

PES schemes have emerged as a potential approach to the provision of local ecosystem services while enabling a participatory approach to catchment management. However, the lack of clearly defined and acknowledged legal duties and responsibilities over water level management, which underlie the provision of ecosystem services for the rest of the catchment, was a key obstacle for the implementation of such participatory and local approach in our case study. While the research shows a willingness to pay to support the implementation of such a scheme by most residents who participated in the survey, clear divergences over the preferred institution to manage such a scheme appeared. This was matched by a lack of clear ownership of the multiple environmental objectives by any of the existing organisations in the catchment area, whose responsibilities focus on a single environmental domain, hindering the identification of a suitable intermediary between the beneficiaries of the ecosystem services and their providers. Local solutions for the provision of multiple ecosystem services at catchment scale require an adequate institutional framework, with clearly defined and acceptable roles and legal responsibilities over both the technical management of the scheme (in our case water levels management) and the set up and implementation of the associated incentive scheme (payment of providers by beneficiaries for the provision of ecosystem services).

CRediT authorship countribution statement

Laure Kuhfuss: conceptualization, methodology, formal analysis, writing – Original draft; **Vanessa Burns:** Formal analysis, writing – Original draft; **Orla Shortall:** Investigation, writing – Review & Editing; **Andy Vinten:** conceptualization, supervision, Writing - Review & Editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2024.107057

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