Financing the Forestry Transition: An Expert Stakeholder Analysis

Edward Knapp[1]*, Kenneth A. Byrne[2,3], W. George Hutchinson[4], Lynn J. Frewer[5] and John Garvey[1]

[1] Kemmy Business School, University of Limerick

[2] School of Biological Sciences, Faculty of Science and Engineering, University of Limerick

[3] Bernal Institute, University of Limerick

[4] W. George Hutchinson, Institute for Global Food Security and Gibson Institute, Queens University Belfast

[5] School of Natural and Environmental Sciences, University of Newcastle

*Corresponding author: Edward Knapp.

Email: edward.knapp@ul.ie.

Address:

KEMMY BUSINESS SCHOOL

UNIVERSITY OF LIMERICK

CASTLETROY

LIMERICK

V94 PH93

Highlights

- Irish land use policies have historically favoured agriculture over forestry
- New funding sources are needed to increase forested area
- Forestry programmes should be local, flexible, and long-term to be successful
- A new public-private funding model is developed using expert advice

Abstract

While afforestation supports several ecosystem services, existing market structures and government policies such as the Common Agriculture Policy have favoured agricultural land uses and afforestation rates have not increased in line with policy goals. To overcome this challenge, novel financial instruments and management mechanisms are needed to compensate for the opportunity cost of transitioning land from agriculture to forestry. This study explores the case of afforestation in Ireland by leveraging expert knowledge via a Delphi survey to identify effective financial structures for the promotion of afforestation with native species which go beyond the existing government forestry subsidy programs. The results of this study suggest that land-use stakeholders recognise the local and national environmental benefits of native afforestation, while also understanding the economic and financial challenges which currently hamper native forestry growth. These results

identify a need for novel financial supports to make the land-use transition to native forestry financially feasible and economically attractive to landowners over the long term.

Keywords

Land management; Land use and land cover change; Afforestation; Forest policy; Farmer decision making; Adoption

1. Introduction

The importance of forest ecosystem services has been researched extensively (Acharya et al., 2019; Krieger, 2001; Mori et al., 2017; Brockerhoff et al., 2017). Forests provide value through regulating services which provide benefits such as carbon sequestration and climate regulation, provisioning services (i.e. timber production), supporting services which benefit biodiversity and habitats, and cultural services such as recreation and aesthetics (Acharya et al., 2019; Mori et al., 2017; Ryan et al., 2022; Thorsen, 1999; Strange et al., 2019; Scarpa et al., 2000; Hutchinson et al., 2001). Given the importance of forest ecosystems, the European Union has set out ambitious forestry policies to meet its climate, biodiversity, and environmental goals (EC, 2021). The current EU Forestry Strategy aims to further the European Green Deal and the EU 2030 Biodiversity Strategy and envisions a central role for forests in helping to achieve sustainability and carbon-neutrality throughout the economy by 2050 (EC, 2021). Specifically, the EU Forestry Strategy requires "larger, healthier, and more diverse forests" to support carbon sequestration, end habitat loss, and mitigate air pollution (EC, 2021). Among the mechanisms to achieve these goals, the EU Forestry Strategy highlights the need for financial incentivisation to make forest ecosystem services provision economically viable for landowners (EC, 2021).

While the importance of forest ecosystem services is widely recognised in the scientific, governmental, and environmental communities, achieving afforestation has been a challenge. Ireland has struggled to achieve afforestation goals and continues to have a low forest cover (only 11.6-14.1 percent of total land area) making Ireland one of least forested countries in the European Union (DAFM, 2022; Eurostat, 2018). This low level of forest cover exists despite strong legal protections for forestry in Ireland which mandate the replanting of forestry and effectively make afforestation a permanent land use change (O'Carroll, 2004, p.35). While the Irish case is extreme, Ireland is not alone among European nations in failing to meet afforestation policy goals (Ryan et al., 2022). Research has identified several barriers to afforestation, including sociocultural opposition at the community level and competition with traditional agricultural land uses (which in themselves support a range of ecosystem services) at the landowner level, as well as uncertainty, irreversibility, (Carroll et al., 2011; Ryan et al., 2022; Song et al., 2020) and information asymmetry between farmers and foresters (Gelo and Koch, 2009). Policy subsidies may partially defray these impacts (Thorsen, 1999), but as many of the barriers are non-monetary in nature, afforestation may not be an appealing option even when the net present value returns from forestry exceed that of agriculture (Weimers and Behan, 2004).

Given the increasing need for ecosystem service delivery and related environmental benefits which forests provides, there exists a knowledge gap in the development of successful financial mechanisms and policies to support afforestation (Forster et al., 2021). To achieve significant changes in land use from agriculture to forestry, strategies must acknowledge the substantial

economic value of forest ecosystem services, while also accounting for the nonmonetary and sociocultural costs faced by landowners transitioning away from traditional land uses. In this context, inflexible, top-down approaches to afforestation are likely to face opposition and fail (Carroll et al., 2011; Ryan et al., 2022). An example of this failure is the local community opposition in several areas of Ireland to non-native, conifer-based forestry (Carroll et al., 2011; Ryan et al., 2022). While native forestry has struggled to expand the Irish dairy sector has grown its economic output substantially over the past decade. In the period 2014 to 2020, milk production by volume increased more in Ireland than in any other European Union (EU) nation (Eurostat, 2021, Bradfield et al., 2021). At the EU level, the dairy sector is the second largest agricultural sector and accounts for more than 12% of EU agricultural output (Augère-Granier, 2018). The elimination of dairy quotas in 2015 allowed profitable dairy farms to expand their land area, herd sizes, and milk output to 8.7 billion litres in 2023 (Bord Bia, 2024). However, this expansion has come at a cost to environmental quality. Examples of the environmental impact of additional dairy cattle include increased nitrate runoff from animal waste which increases nutrient loads and can contribute to diminished water quality in lakes and rivers. Furthermore, dairy cattle are a significant source of Ireland's greenhouse gas emissions (GHGs) via cattle methane gas emissions and emissions of nitrous oxide from cattle manure and dairy production has the highest GHG emissions profile of any Irish farm system (Herron et al., 2022; Duffy et al., 2020). It is important to note, however, that the economic benefits and environmental costs of an expanding dairy sector accrue not only at the farm level, but also at the level of dairy processors in Ireland. The Irish diary processing sector is large with a gross value added of 4.3 billion euro while supporting a dairy export value of 6.3 billion euro in 2023 along with 53,930 jobs (Bord Bia, 2024; Ernst and Young, 2023).

This study applies a Delphi approach to examine the barriers and the adoption pathways for afforestation with native Irish tree species (largely deciduous trees) on land currently used for dairy farming in Ireland. Irish dairy farms are generally more profitable and market-oriented than other Irish farm systems (Hennessy and Moran, 2015; Knapp and Loughrey, 2017). Ryan et al. (2022) note that Irish dairy farmers have been reluctant to undertake afforestation. However, increasing environmental pressures as well as close ties with other parts of the dairy supply chain may create the enabling conditions for the development of targeted financing of afforestation. Financial support for land use change has the potential to mitigate environmental impacts that arise from emissions and deteriorating water quality (Duffy et al., 2020; another reference on water quality might be good here). Native afforestation may be better placed to overcome the sociocultural barriers faced by spruce monocultures, while also contributing a broader and more resilient set of ecosystem services (Carroll et al., 2011). Native afforestation using slow growing broadleaves, such as oak, has increased life-cycle carbon storage benefits in the long-term when compared to non-native afforestation with conifers (Catovsky and Bazzaz, 2000; Bullock et al., 2014; Bullock et al., 2016). Forests have also been found to be an effective nature-based solution to improve water quality in nearby surface water in Ireland (Bullock et al., 2014; Bullock et al., 2016; Heneghan et al., 2021), Brazil (Piffer et al., 2021) Chile (Little et al., 2015), New Zealand (Quinn and Stroud, 2002; Scarsbrook and Halliday, 1999) and Costa Rica (Brumberg et al, 2021).

The Delphi approach is used in the current study to identify the design features for a financial instrument that can incentivise the creation of native forestry (and the critical ecosystem services which it provides) through land use change on Irish dairy farms. To this end, a heterogeneous knowledge pool of 36 experts were engaged using the Delphi method (Linstone and

Turoff, 1975) to elicit expert opinions and preferences on the general strategy to achieve native forestry goals as well as the particular aspects of financial instrument architecture necessary for successful implementation. Sustainable finance solutions (particularly private sector applications) do not have an extensive history in Ireland. In addition, the dairy sector has been the subject of a decade-long intensification period. Expert elicitation is needed to identify facilitators of, and barriers to, land use change in relation to increased afforestation and transitions to net zero carbon emissions. Specifically, it considers financing innovations as mechanisms to increase native afforestation in this sector. To date, no quantitative research has been conducted into the mechanisms which could support native afforestation on dairy farms in Ireland. Given the lack of existing empirical data, the Delphi approach is suitable as "the investigation at hand does not lend itself to precise analytical techniques but can benefit greatly from subjective judgements on a collective basis" (Grisham, 2008, p114).

Following the deliberative research approach of Shipley et al. (2020) and the scenario analysis method of Ehlers et al. (2022), an in-depth, in-person discussion group was applied to further define the results which emerged from two-round Delphi method survey. This approach is appropriate to analyse this complex and understudied issue, especially in relation to future decisions and actions (Grisham 2009; Ehlers et al., 2022). While stakeholder perceptions of afforestation given *existing* forestry funding mechanisms have been studied in such works as Ní Dhubháin, et al. (2009) and Ryan et al. (2022), the requirements and stakeholder acceptability of potential future financing strategies and mechanisms to support native afforestation has not yet been studied. The economic valuation of rural ecosystem services emanating from both agriculture and forestry is complex, but must be addressed if land use change is to support the transition towards a net zero carbon emissions economy (Shipley et al., 2020).

1.1 Financial literacy and land use

The decision faced by Irish farmers to change the land-use of their property from agriculture to native forestry is a financially complex one (Źróbek-Różańska et al., 2014; Ryan and O'Donoghue, 2016). While government and potential private sector afforestation support mechanisms benefit farmers, these are often paid over a finite time horizon and must be balanced against the opportunity cost of lost agricultural earnings and European Union Common Agricultural Policy direct subsidy payments, as well as potentially complicating inter-generational land transfer and related tax liabilities. These costs are in addition to the non-pecuniary social and cultural costs of afforestation. In this context, the financial literacy of land managers becomes a critical component of their decision-making process.

Research has found that financial literacy significantly impacts land management decisions such as those relating to farmland transfer (Tan et al., 2022); borrowing, the use of farm assets as collateral for credit, and credit management (Guo et al., 2023); and resource allocation (Lusardi et al., 2017). In the specific context of forestry, Guo et al. (2023) found that financially literate farmers could effectively use forest land as collateral to improve access to credit. This result encourages the potential use of forestry as collateral as part of a private sector afforestation scheme in Ireland. Financial literacy is also associated with improved savings outcomes (Lusardi et al., 2017). These results are supportive of policies which encourage financial literacy among farmers, especially low-income farmers, in the areas of "…the lending process, interest rates, loan terms, and awareness of the risks and benefits of household financial strategies." (Guo et al., 2023; Tan et al., 2022).

1.2 Irish forestry context

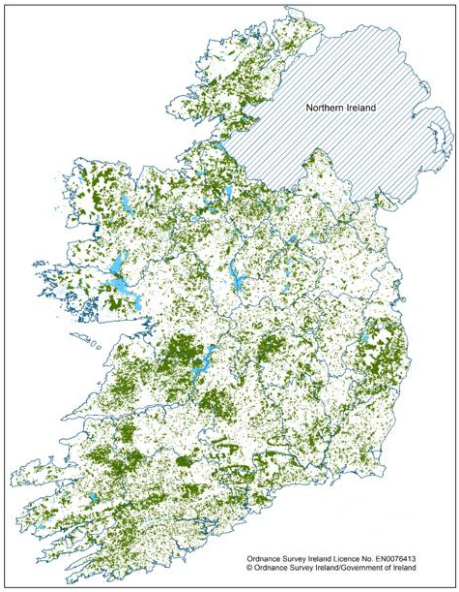
Forests in Ireland began to be steadily diminished during the Iron Age in the 3rd century BCE and continued to be cleared through the Industrial Age of the 19th century CE (O'Carroll, 2004, p.5; McMahon, 2023, pp. 43-44). Population expansion in Ireland to more than eight million people by 1841 led to deforestation to both increase food production and supply the forest product needs of the industrial economy (O'Carroll, 2004, p.5; McCracken, 1971). Land reform policies, which from 1870 began to redistribute land to small-holding farmers, further contributed to deforestation as private woodlands within large estates were deforested and converted to agricultural use (O'Carroll, 2004, p.10; McMahon, 2023, p. 106). During the land reform process and throughout the 19th and early 20th centuries forestry developed a negative connotation as "Trees were associated with landlords." (O'Carroll, 2004, p.12; Neeson, 1991, p. 102; McMahon, 2023, p. 101).

Since the foundation of the Irish State in 1922, Ireland has struggled to recover from centuries of deforestation and has attempted to increase forest land area from a very low base (DAFM, 2022). The first Irish limited afforestation policies and forest grant payments began as early as 1922 (Neeson, 1991). However, by 1928, the Irish government estimated that only 1.2 percent of Ireland's land area was forested, the lowest percentage on record (Minister for Lands and Agriculture, 1928). In 1946, the Forestry Act enshrined in law the obligation to replant, within twelve months of felling, all cleared forest land (O'Carroll, 2004, p.35). Thus, afforestation became a permanent and irreversible land-use change. Despite these policies, Ireland's stock of forest land remained low through most of the twentieth century, with the forested area not exceeding 5 percent until 1985 and not exceeding 10 percent until 2006 (DAFM, 2022). The increases in forested area from the 1980s onwards were stimulated by European Economic Community Forest incentives which were launched in 1981, and by national policies including the Forestry Operational Programme and the Operational Programme for Rural Development which began in 1989 as well as the Forest Premium Scheme in 1990 (Ryan et al., 2022).

At present, Irish forestry policies seek to preserve and expand Ireland's stock of private and public forested land. In fact, the Irish Government has planned a transformational increase in forest land use order to support biodiversity, mitigate climate change, and improve water quality among other reasons. According to Ireland's Forest Strategy 2023-2030, the Government has ambition to afforest 8,000ha of land per year during the 2023 to 2030 period. Also planned is an increase in forested area from 11.6% to 18% of land area by 2050 (DAFM, 2023a). To achieve this goal, Ireland along with several other European nations such as the United Kingdom, Switzerland, Denmark, Croatia, Finland, Portugal, Germany, and France use policies and grant subsidies to incentivise and stimulate afforestation (Ryan et al., 2022; Raum, 2017; Thees et al., 2020; Madsen, 2003, Neidzweidz et al., 2011; EC, 2021). In this context, Irish forestry policy aims are twofold: to continue to support the forestry industry (which is currently centred on non-native tree species) while also providing an alternative income stream to farmers in the context of increasing competition and farm consolidation (Carroll et al., 2011). To date, these government policies have had limited success in stimulating substantial changes in land use to forest (Ryan et al., 2022). While government-based afforestation programmes have been a central component of Irish forestry policy for decades, private-sector support for afforestation has not yet been implemented and has the potential to overcome certain pitfalls faced by public sector programmes. Alternate sources and mechanisms of funding from industries such as finance and/or the dairy processing sector have the potential to reduce the administrative burden of afforestation, provide longer-term funding streams, and build

trust-based relationships with farmer landowners and community members at the local level (UN, 2023; Clarke et al., 2018). Examples of private sector financing for forestry include programmes in Australia (Ferguson et al., 2016), New Zealand (Hall et al. 2017), and the United States Madeira and Gartner, 2018; Bernknopf and Broadbent, 2020; Brand et al., 2021; Thompson, 2023). Programmes like these, if implemented in the Irish context, could help to substantially improve the current forestry situation in Ireland which is one of low forest area with approximately half (49.1 percent) of Ireland's forested land being publicly held, mainly by the State-owned forestry company, Coillte (DAFM, 2023a; Eurostat, 2018). The majority (69.4%) of Ireland's forest area is populated with conifers with the primary conifer species being non-native Sitka Spruce covering 44.6 percent of forest area (DAFMa, 2023; Carroll et al., 2011; Ryan et al., 2016). Ireland's forests are also relatively young with seventy percent of forest area being less than seventy years old (DAFM, 2023a). Figure 1 below illustrates Ireland's forested area (in green) as of 2017.

Figure 1. Map of Forest Cover in Ireland



Source: DAFM (2023b)
© Tailte Éireann
Copyright Permit No. MP 000524

Tailte Éireann
Clárúchán, Luacháil, Suirbhéireacht
Registration, Valuation, Surveying

In considering the design of a financial instrument directed towards land use change, the concept of a real option is highly relevant to the framing of the afforestation decision. Rather than valuing decision-making solely based on net-present-value of returns, which only considers the impact of time-value of money on returns, real option valuation also considers the concepts of uncertainty of returns and irreversibility of decisions (Yemshanov et al., 2015). This theory is relevant in the context of native afforestation where returns (both monetary and nonmonetary) are accrued over multiple decades and sources of uncertainty range from policy risk to climatic instability to land value volatility (Yemshanov et al., 2015). In the context of dairy farming, economic uncertainty is particularly acute when production, market, and policy risks are considered (Garvey et al., 2019). Furthermore, dairy farmers who plant native forestry sacrifice the operational and management flexibility of grass-based livestock production and must be able to access long-term compensation to make forestry an economically attractive real option (Gazheli and Di Corato, 2013). This compensation may be provided by public and/or private actors such as the dairy processing sector and should provide financial certainty to farmers via predictable cash flows. In addition to cash forestry subsidies, other financial benefits from the private sector such as milk price bonuses, less volatile prices in milk delivery contracts, or lower cost loans in return for afforestation may help to mitigate uncertainty for dairy farmers who face short-term policy, weather, and market risks, but have long-term fixed costs such as land, livestock, and infrastructure (Garvey et al., 2019). This steady afforestation income can act as a hedge against the income volatility inherent in dairy farming (Gazheli and Di Corato, 2013). Given that development of land in many scenarios is irreversible (particularly in the present case of afforestation), and the benefits accruing to development are uncertain, preservation was reported to be economically viable across a wider

range of scenarios compared to when simple net present value of returns had been used as the valuation tool.

In the case of forest, real option analysis has been applied by Thorsen (1999) and Yemshanov et al. (2015) to the afforestation decision. More recently Strange et al. (2019) applied this analysis to afforestation of agricultural land. The results suggest that consideration of uncertainty is important in afforestation decision-making, which is incentivised by more than simply the net present value of forestry returns plus subsidy payments (Thorsen, 1999; Strange et al., 2019). Landowners face uncertainty not only in terms of uncertain returns from agriculture and forestry, but uncertainty about future government forestry policies, agricultural policies such as the Common Agriculture Policy of the European Union, and changing land values (Thorsen, 1999; Yemshanov et al., 2015). Irreversibility also impacts decision making about the value of forest versus the preservation of agricultural land given that afforestation is legally irreversible in Ireland (Strange et al., 2019). Given the non-market nature of many of the benefits which accrue from afforestation, their expected future value is uncertain (Strange et al., 2019). As an example, recreational benefits and other cultural ecosystem services may become more valuable where natural areas become scarce due to increasing urban sprawl (O'Driscoll, 2023; Ahrens and Lyons, 2019). However, benefits from ecosystem services may lose value if the land uses surrounding the afforested area inhibit the provision of ecosystem services in the locality (Strange et al., 2019).

2. Methods

This study applies a deliberative approach to the problem of forestry financing mechanism development and applies the approach of Shipley at al. (2020) and Ehlers et al. (2022). This approach involves a multi-stage Delphi survey followed by an in-person discussion which allows for live dialogue between the expert panellists. Given that various monetary and non-monetary values hang in the balance, deliberation among a heterogeneous group of experts and stakeholders is required to consider the diversity of viewpoints in the decision-making process (Shipley et al., 2020; Kenter et al., 2019). The in-person workshop also allows for scenario analysis which facilitates dialogue, deliberation, and consensus amongst stakeholders in an area of uncertainty and complexity (Ehlers et al., 2022).

According to Linstone and Turoff (1975), the Delphi method is a structured, iterative inquiry process of gathering the anonymous viewpoints from a group of experts in the research area. This method can be utilised in various ways, such as developing expert consensus or identifying points of dissensus (Kendall et al., 2018). Delphi surveys typically involve multiple rounds of submitting survey questionnaires to the expert respondent group (Kendall et al., 2018). These surveys may include both open-ended and structured questions (Ehlers et al., 2021). After each survey round respondents have the option to refine their answers based on feedback about group responses (Walters et al., 2021) or individual narrative comments justifying scores (Frewer et al., 2011). While increasing the number of survey rounds offers additional opportunities for consensus building, increasing the number of survey rounds also increases the likelihood of panellist dropout (Belton et al., 2019). A key role in a Delphi survey is that of the coordinator or administrator who makes judgment-based decisions on the method structure and facilitates the collation selection, and presentation of the results from one survey round to the next (Belton et al., 2019). Participants in the expert respondent group do not know who the other participants are (Grisham, 2009). The anonymous nature of the Delphi process allows for more varied views and interpretations of an issue

than a traditional group meeting by eliminating the possibility of certain individuals dominating the discussion and crowding out other opinions i.e. “groupthink” (Belton et al., 2019; Shipley et al., 2019). This anonymity further serves to minimise individual-level bias associated with personal experiences and interpersonal interactions (Grisham, 2009). Other features of the Delphi method include its usability in resource-constrained, high complexity research environments where stakeholder views are often difficult to rigorously quantify and to incorporate into effective policies (Walter et al., 2021; Shipley et al., 2020). The Delphi method has been applied in various research fields including in areas relevant to this study such as the agri-food sector (Ehlers et al., 2022; Kendall et al,2018), the ecology of land-use changes (Wolf et al., 2023; Mack et al, 2023), agro-environmental management (Triana et al., 2022), rural landscape ecosystem services (Shipley et al., 2020), and ecosystem services assessment (Walters et al., 2021).

2.1 Sampling experts

Based on the conceptual continuum developed by of Donahoe and Needham (2009) and Devaney and Henchion (2018) and the expertise and knowledgeability requirements of Wolf et al. (2023) and Grisham (2009), a heterogenous set of 36 experts from across the agri-food industry, government policy, and academia were sampled. The experts are categorised based on three levels of closeness (subjective, mandated, and objective closeness to the research question) (Devaney and Henchion, 2018). The subjective closeness category includes stakeholders with direct, experiential knowledge in the industry of study (Devaney and Henchion, 2018). Experts with subjective closeness to the aims of the research include executives from the dairy industry, intensive and extensive dairy farmers, representatives of farmer and industry advocacy groups, and executives from financial institutions. Mandated closeness can be described as a professional, legal, regulatory, or policy relationship with the area of analysis (Devaney and Henchion, 2018). Study participants with expertise in the mandated closeness range of the expertise continuum include policy makers in the agri-food space as well as farm advisors with experience in the dairy sector. Stakeholders exhibiting objective closeness derive their expertise in the topic of interest via unbiased academic study and research (Devaney and Henchion, 2018). Academics with forestry and/or agri-food research experience represent objective expertise in the present study. Figure 2 below illustrates the conceptual continuum of Donahoe and Needham (2009) Devaney and Henchion (2018) as applied in this research. Figure 2. The conceptual continuum of expertise. Adapted from Devaney and Henchion (2018)

The experts were located across the island of Ireland, that is the Republic of Ireland and Northern Ireland. This allows the unique historical and sociocultural aspects of land use in Ireland to be captured in the expertise base. Panellists maintained anonymity from each other during the two survey phases, which allowed for consensus building and the honest sharing of opinions without the influence of dominant individuals. The results were further explored by participants at the in-person discussion group following the Delphi survey.

2.2 Delphi Survey

The Delphi survey instrument was drafted and piloted with six expert pilot respondents in March of 2023. In August of 2023, a revised survey instrument was submitted electronically to the complete panel of 36 experts. The expert participants were invited to participate in a two-round Delphi method survey on the topic of native afforestation on dairy pasture in Ireland. Participants were also informed of and invited to the optional in-person scenario workshop to be held following the completion of all Delphi survey rounds. Sampled experts were asked to complete the electronic survey instrument independently and return the completed round-one survey questionnaire electronically within a two-week deadline. In the first round of the Delphi survey, 19 respondents completed the survey. In the second round, 12 respondents completed the survey. Overall, the responding experts represent a rich and heterogeneous pool of expertise. See tables 1 and 2 below for a demographic breakdown of the sample.

The Delphi survey questionnaire (available from the corresponding author upon request) was developed to minimise respondent burden while simultaneously eliciting expert opinion through structured and open-ended questions on the benefits, costs, and feasibility of developing a new financial instrument to support native afforestation in Ireland. The structured questions required answers ("I don't know" was an option) for survey completion while unstructured or open-ended questions were optional and could be left blank. The round-one survey included ten structured questions on the topic of the benefits of afforestation benefits and financing. After each structured question, respondents were prompted to answer an unstructured, follow-up question to explain their answer. In addition to the afforestation questions, demographic information was collected from respondents including age, education, occupation, and years of experience.

After the conclusion of the three-week round-one response period, respondent data was collated and the group responses of the structured questions were summarised for presentation to round-two participants following the method of Walters et al. (2021). The survey coordinators also analysed the responses to the unstructured questions provided quotes representing the different viewpoints of the sample.

The same sample of experts was asked to respond to the round 2 survey beginning on October 1st, 2023. Survey questions from round 1 were repeated except for those questions where consensus had been reached. In the Delphi method literature, the definition of consensus varies widely (Diamond et al., 2014). While Kher et al. (2010) use 50% as the threshold and Kendall et al. (2018) use greater than 60%, Diamond et al. (2014) systematically reviewed Delphi studies in the literature and found that the median consensus threshold was 75%. Based on the need to highlight areas of strong agreement, the present study uses 75% as the consensus threshold. Therefore, questions with greater than 75% agreement were not repeated in round 2 as consensus had already been achieved among the expert panellists. This resulted in two questions referring to these issues being

dropped from the round 2 questionnaire. Two additional questions were included based on the qualitative responses of the experts. One new question was asked about possible economic features of a hypothetical successful native forestry scheme. The other new question asked about possible financial features of a hypothetical successful native forestry scheme. Before being asked to answer repeated questions from round 1, respondents were prompted with feedback showing the simplified results of the round 1 survey for each question where disagreement occurred. Respondents were also shown two quotes from the long-answer qualitative questions which were representative of the alternative viewpoints of the sample. Tables 1 and 2 below illustrate the diversity of respondents to the Delphi survey rounds 1 and 2 respectively including academics, farmers, and farm advisors of varying ages, genders, and experience levels. It should be noted that dairy farmers' perceptions of forestry have been found by Dhubháin et al. (2009) to be influenced by individual level farmland area and land availability. This survey did not ask the farmers who were included in the sample to report the land area of their respective farms.

Table 1. Attributes of Delphi survey participants Round 1 (n=19)

Profession	Gender			Highest educational attainment		Age		Experience	
	Female	Male	Other	Secondary/Technical	Tertiary	<=40	>40	<= 20 years	>20 years
Academia	2	1			4	1	2	4	
Agricultural/ forestry advisor*	1	4	1		6	1	4	2	4
Dairy farmer		3		2	1	1	1	1	2
Financial institution		1			1		1		1
Other	1	3		1	3	2	2	2	2
Public policy		1			1			1	

Note: Some respondents preferred not to respond to gender and age demographic questions.

Table 2. Attributes of Delphi survey participants Round 2 (n=12)

Profession	Gender			Highest educational attainment		Age		Experience	
	Female	Male	Other	Secondary/Technical	Tertiary	<=40	>40	<= 20 years	>20 years
Academia	2	1			3	1	1	3	
Agricultural/ forestry advisor*	1	4			5	1	4	2	3
Dairy farmer		1		1			1		1
Other		2		1	1	1	1	1	1

Note: One respondent did not provide career background information.

2.3 Discussion group

The scenario workshop structure was adapted from that of Ehlers et al. (2022) and Shipley et al. (2020). Expert participants who completed rounds one and two of the Delphi survey were invited to attend an in-person scenario workshop which was conducted in Limerick, Ireland in December 2023 and attended by 6 of the sampled experts representing respectively, farmers, a forestry industry group, a dairy industry group, an environmental group, a forestry advisor, and academia. Two of the participating discussants are current dairy farmers. This workshop was conducted in three phases. Firstly, the summarised results of the round-two Delphi method survey were presented by the survey coordinators to the assembled participant experts. Experts were given opportunity to ask questions about the survey, its results, and possible implications of this research. Under the supervision of two discussion facilitators, experts in the discussion group discussed the barriers to native afforestation as well as potential opportunities for land-use change toward native reafforestation. The discussion was transcribed verbatim.

The respondents to the two-round Delphi Survey highlighted the benefits of afforestation including national environmental benefits. The panel also observed the challenges around gaining market acceptance from both the dairy and finance industries. The discussion group which followed the Delphi survey allowed for increased stakeholder engagement and offered invaluable local expert insights to the research coordinators. Participants in the follow-on discussion group provided further qualitative detail and validation to the data collected in the Delphi survey. This research approach established the feasibility of native afforestation financing schemes and generated consensus around the features of financing mechanisms which could be incorporated into future agro-environmental policy.

After the in-person discussion, the core project team including the discussion coordinators reviewed the discussion results and categorised the discussion findings into two broad themes. These themes were barriers to afforestation in Ireland and opportunities for land use change in Ireland towards afforestation. Following the review by the core project team, a brief summary of the discussion findings, along with highlighted results of the Delphi survey rounds one and two, were shared with agricultural and environmental economics experts at a seminar in Dublin, Ireland in January 2024. These experts broadly concurred with the discussion and survey findings.

3. Results and Discussion

3.1 Delphi survey results

Despite the diverse viewpoints and heterogeneous experiential backgrounds of the expert panel convened for this study, the results of this Delphi survey demonstrated multiple areas of strong agreement. Table 3 below shows the survey questions in both survey rounds which yielded consensus, i.e. 75 percent or more of respondents reported the same answer. In round 1 of the survey, respondents agreed on the environmental benefits of native afforestation and 90 percent of respondents agreed that native afforestation in Ireland offers benefits at the national scale. After being prompted with the results of the round 1 survey, two additional questions garnered agreement levels above the consensus threshold. A strong majority of round 2 respondents (92 percent) thought that the dairy industry was unlikely to compensate farmers to encourage land use change to native forestry and furthermore 83 percent of respondents did not see native afforestation compensation as the role of the dairy industry. It is important to note here the context in which

survey participants were queried on the role of the dairy industry in native afforestation. While the Irish dairy sector has and continues to market its green image through such programmes as Bord Bia's Origin Green Dairy (Origin Green, 2024) and IBEC Dairy Sustainability Ireland (Dairy Industry Ireland, 2017), the sector has not yet become involved in forestry or other direct GHG mitigation or offsetting measures. This is despite calls by the United Nations to encourage private financing of GHG mitigation efforts (UN, 2023). Furthermore, there currently is no government structure or policy currently in place In Ireland to facilitate private sector financial involvement in native afforestation programmes such as private funding "topping up" existing forestry premium amounts. If policy mechanisms were implemented in the future, it could be within the strategic interest of industry stakeholders to participate in forestry financing.

Table 3. Points of consensus

Survey round	Survey question	Result	Respondent quote example
1	Native afforestation offers environmental benefits.	100% agreed	"…I'm seeing a big change in positive attitude towards the environment…"
1	Native afforestation benefits Ireland as a whole.	90% agreed	"I would say native afforestation can benefit everyone…when implemented correctly."
2	Would the dairy industry provide fair compensation to support change in land use by dairy farmers?	92% thought it was unlikely	"Unlikely, unless support for afforestation is translated as a "licence to farm" i.e. building social capital amongst the dairy industry's mainly urban customer base."
2	The dairy industry should compensate farmers who plant native forestry	83% disagreed	"I don't think it is the role of the dairy industry to be responsible for the paying of the compensation."

Even after respondents were shown the round 1 survey results, less than three quarters of respondents were in agreement on the questions shown below in Table 4. Two thirds of respondents thought that short-term (within two years) land use change on dairy farms was unlikely despite the existing government afforestation support programmes. This result underscores the need for novel afforestation financing mechanisms. An interesting result was that two thirds of respondents thought that native afforestation would not negatively impact production on dairy farms. This response suggests that some reforestation could occur without hampering the primary agricultural enterprise of dairy farms. In parallel with the responses on the role of the dairy industry, most respondents (66 percent) thought that the financial industry did not have a role in encouraging farmers to establish native forests. Again, it is important to note that respondents were asked about the role of the financial industry in the present policy context which is one of a lack of policy guidelines for private investment into afforestation or sustainability in general. Sources such as Clarke et al. (2018) and UN (2023) highlight the importance of policies which mobilise private sector finance to achieve sustainability goals.

Table 4. Points of dissensus (less than 75% agreement among respondents)

Survey round	Survey question	Result	Respondent quote example
2	What is the likelihood that dairy farmers in Ireland will change some part of their land area away from grassland and towards native forestry during the next two years?	33% thought it likely, 66% thought it unlikely	"There would need to be a big change towards incentivising farmers to do so, and/or a change in regulation."
2	Would native afforestation on dairy farms help to reach national targets for carbon sequestration and/or biodiversity?	50% thought little or no impact, 50% thought moderate or significant impact	"The levels of sequestration would possibly be modest due to the slower growth rates, the biggest results would be for biodiversity as it is the most sustainable environment for Irish wildlife."
2	Would native afforestation on dairy farms negatively impact milk production?	66% thought little or no impact, 33% thought moderate or significant impact	"A less intensive, more balanced farm will still produce milk if the herd is less stressed."
2	Should the financial industry compensate dairy farmers who plant native forestry?	33% agreed, 66% disagreed	"Involving more corporate entities in financing such projects would only give them an opportunity for green washing their activities."

The Round 2 survey was distributed to respondents on 12/10/2023 and was closed on 25/10/2023.

The second-round survey asked members of the expert panel about their preferred financial and economic features in a native afforestation support programme. The features which survey participants were prompted with were derived from the programme features mentioned in free-response comments by round 1 participants. The most preferred economic features highlighted by respondents were "additional payments to support biodiversity", "funding for farmer education and market support to generate a business income from forestry", and additional payments for carbon sequestration. In terms of preferred financial features in a native afforestation programme, respondents chose "incorporating forestry payments in succession plans to benefit multiple generations", "extend payments over a longer time-period, and "participation in afforestation programmes provides farmers with access to lower cost loans". In both the structured and free response queries of ideal programme features, respondents were most concerned with ensuring that native afforestation would yield a long-term, sustainable funding stream which could help to maintain farm viability on a multi-generational timescale.

3.2 Discussion group results

The in-person discussion group elicited a wide-ranging conversation amongst the assembled participants. In broad terms, the discussion can be summarised into two themes: barriers to afforestation and opportunities for afforestation. Barriers to afforestation are described in Figure 3 below. This figure illustrates the policy barriers raised by discussants which include lack of trust in government to follow through on long-term forestry policies as well as cumbersome bureaucracy which makes afforestation a slow process with the added pitfall of limited eligibility. An equally

important set of afforestation barriers derives from the significant social and peer pressures faced by farmers. Farmer discussants highlighted the pressure they face from their social network to use land productively and maintain their farmer identity or face social exclusion. While stakeholder discussants highlighted the most important barriers shown in Figure 3 below, they also noted that other myriad and multifaceted obstacles (both known and unknown) stand in the way of native afforestation.

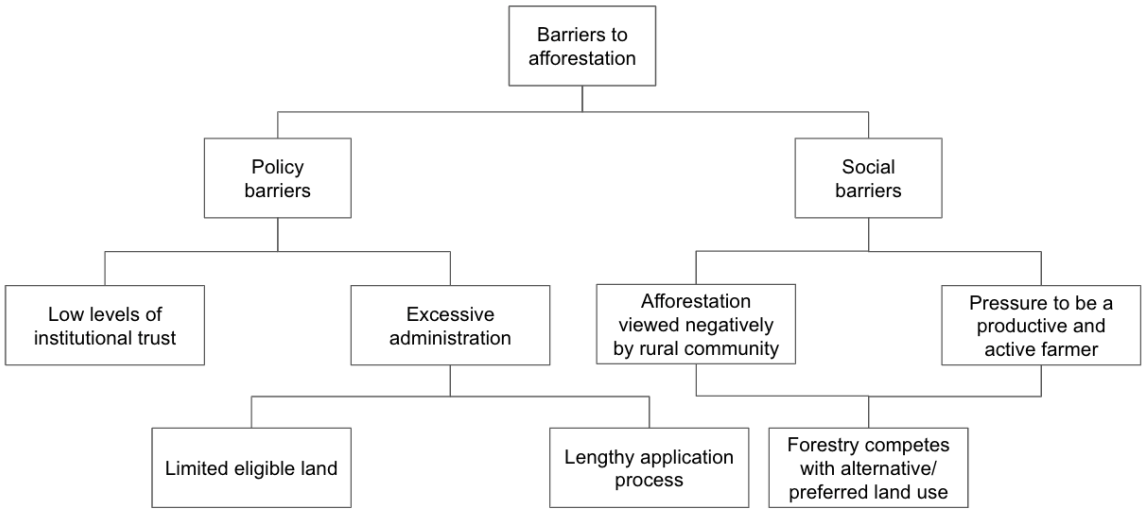


Figure 3 Discussion Group Themes (Barriers to Afforestation). Two dominant themes emerged as barriers to afforestation. Policy barriers comprised of a deterioration in levels of trust in government due to the poor prior history on long-term support for afforestation. Within the policy domain, excessive administration was linked to issues around identifying eligible land, as many wetlands and protected habitats were excluded from afforestation. This was compounded by a lengthy application process (2-3 years). Social barriers were identified as a second significant barriers as production efficiency and proactivity in land management were prioritised. Also, farmers who considered or undertook afforestation were viewed as making that land unavailable to other local landowners who would have valued its availability to increase their own productive capacity.

Despite the several barriers to afforestation faced by landowners, the expert stakeholders in the discussion did identify multiple opportunity pathways towards land use change. Figure 4 below illustrates the ideal underpinnings of a successful programme of native afforestation. Such a program would leverage local farmer forestry networks to address local afforestation needs. Discussants contrasted this ideal with current government afforestation programmes which are national in scale. Another opportunity pathway which was mentioned by both farmers and forestry advisors in the discussion group is the need for native forestry planning at the multi-generational timescale. Given the long growth cycle of native broadleaf forestry and the desire of farmers to pass on their land as a productive and financially sustaining asset to the next generation, discussants felt that the current native afforestation programme timescale of ten years was too short. The final area of afforestation opportunities was identified by discussants as a shift in the forestry paradigm in Ireland which traditionally focused on large-scale, non-native conifer forests. Several discussants felt that small-scale native afforestation could be implemented in harmony with agricultural production. This result echoed the Delphi survey finding that a majority of respondents felt forestry could be implemented without a negative impact on dairy production. In addition, discussants stated that

forestry can benefit agricultural enterprises such as by mitigating nutrient runoff and therefore aiding in environmental compliance.

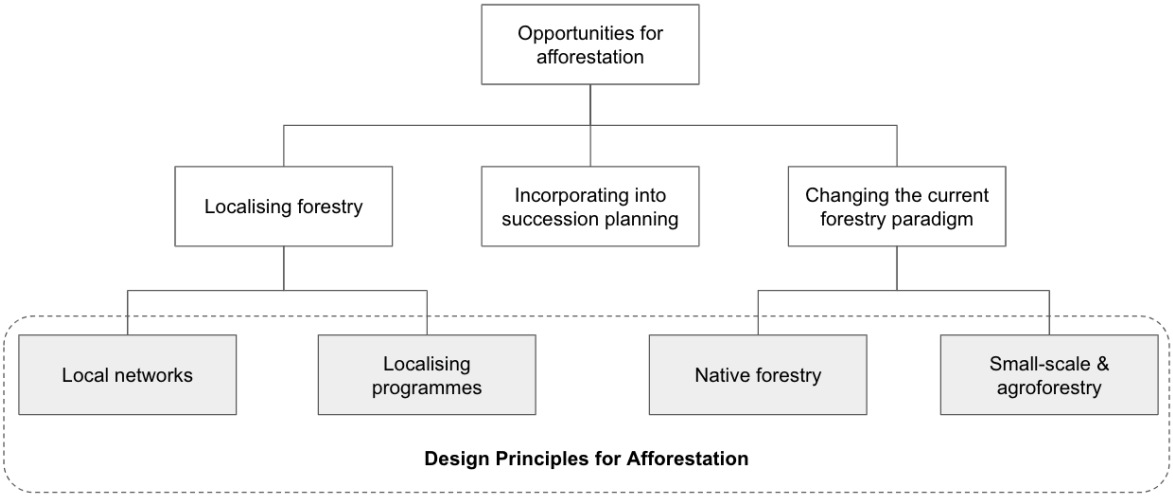


Figure 4 Discussion Group Themes (Opportunities for Afforestation). Design principles to enhance existing afforestation programmes emerged from the third phase of the Delphi method. The discussion on opportunities for afforestation focused on localising forestry efforts using existing farmer networks and designing specific interventions based on local landscapes. Improved take-up of afforestation within this local context was expected to be realised through a focus on native afforestation and small-scale woodlands and/or agroforestry.

The opportunities for local forestry visualised in Figure 4 above coalesce around four key design features which are critical to the success of a novel financial mechanism to support native afforestation. Stakeholders who participated in this study identify, localised forestry programmes that leverage existing farmer networks, prioritise native tress species and are implemented via small-scale forests and agroforestry. Financial instruments that can successfully implement this approach may complement national forestry programmes and incentivise increased adoption of afforestation by Irish landowners. The expert stakeholders emphasised the need for customisability and flexibility as a key feature in a novel native afforestation programme. These results support McMahon (2023, pp. 159, 165) who recommends the use of continuous cover forestry (CCF) which is legally required in Switzerland, Slovenia, and parts of Germany and Denmark, but the current Irish forest subsidy policy for CCF prescribes specific species (mostly non-native conifers), a specific planting layout, and provides lower subsidy (premium) amounts than for forestry systems that involve clearfelling (DAFM, 2023c). The current restrictive requirements have ultimately led to low uptake of the CCF scheme in Ireland (McMahon, 2023, p. 165).

The results highlight the need for longer term, multigenerational payments to farmer landowners for afforestation. However, as described by UN (2023) government short-termism and a lack of policy structures to leverage private financing have left farmers with a choice between indefinite income and social benefits from farming and relatively short-term afforestation payments along with concomitant negative impacts on social standing in the farming community. Given this decision, many Irish farmers are reluctant to participate in existing public sector native forestry programmes. While the expert participants in this study negated the role of the finance and dairy processing sectors in afforestation, this result further underscores the need for government to set

the foundations for private sector involvement in afforestation. The private sector can allow for increased compensation to farmers, longer payment periods, and may reduce the bureaucratic burden of solely public programmes.

Land use competition is another barrier to be hurdled by any prospective programme for large-scale native afforestation. At the national level, expanding agricultural area, protected wetland areas, and endangered species habitats all compete with forestry for land access. Individually, farmers struggle to access land and maintain enough agricultural area for farm viability. These farmer/landowners face financial constraints and are comparing projected long run agricultural returns with forestry premia that currently terminate after ten to twenty years. In this context of regulatory, land, and financial constraints, afforestation rates have remained low. Results from this study, in particular from the post-survey discussion, recommend local community scale programmes that can use more flexible strategies adapted to the needs of the individual landowners and the local area. Forestry benefits to individual farmers include longer grazing periods and nutrient control while local communities can benefit from improved water quality, flood control, and forestry recreational opportunities. To unlock these benefits, local communities, forestry cooperatives, and farmer networks need flexible, bottom-up solutions such as customised continuous cover forestry which would allow the species best suited to the local pedoclimatic conditions to be grown and harvested gradually, ensuring a steady flow of long-term income. Another example of localised needs is silviculture or agroforestry. While current policy does support combining agriculture and forestry in the same land area, it does so in a highly prescriptive way which does not consider regional and local variations in agricultural systems, soils, climate, and culture.

3.3 Integrating design principles into a financial instrument

The results of this study support the development of a novel financing mechanism which leverages the recent growth in the conservation finance market (Herrera et al., 2019) and can be structured around specific policy goals as well as the environmental pressures arising from increased dairy production in recent years. One feature of native afforestation is its ability to improve water quality when forestry is planted near surface water bodies as a riparian buffer between surface water and agriculture. By controlling soil erosion and intercepting agricultural nutrient runoff, trees can improve surface water quality at the catchment level in water catchment suffering from high nutrient loads. Riparian buffer zones, which are a type of land sparing (Meli et al., 2019; Phalan, 2018; Witing et al., 2022), feature prominently in environmental programmes in Ireland and elsewhere. The current environmental component of the CAP subsidy payments in Ireland, Agri-Climate Rural Environmental Scheme (ACRES), currently provides farmers with payments up to €1,530 per hectare, per year for five years to restrict livestock access from up to two hectares of riparian buffer zones. Irish farmers can also avail of the Native Tree Area Scheme, NTA 2, Forests for Water Protection which funds tree planting and livestock fencing along watercourses and also provides farmers with annual premia of €2,284 per hectare, per year for ten years. In the United States, similar buffer zones are supported financially by the Conservation Reserve Programme (CRP) which supports the re-establishment of land cover to reduce soil erosion and improve water quality (USDA, 2024). While public conservation funding programmes exist, they face a global shortfall in funding when compared to their conservation goals (Huwyler et al., 2014). This prompts a need for novel private-sector conservation finance mechanisms in order to close the conservation funding gap.or Pay-for-Success

Novel nature-based solutions and the programmes to support them can be supported by the findings of this study. In order to achieve environmental goals such as surface water quality protection via forestry, a voluntary pilot scheme of results-based payments (also known as Pay-for-Performance or Pay-for-Success (Herrera et al., 2019)) for ecosystem services is proposed. This proposed scheme would direct results-based payments towards farmers based on an environmental quality scorecard at the individual and watershed catchment levels. By merging a results-based payments for ecosystem services scheme with the key features to support a novel native afforestation financing mechanism, multiple environmental benefits can be achieved simultaneously. The conceptual map shown below in Figure 5 integrates the design principles (local, customisable, native, and small scale) which were identified in the Delphi survey and discussion group results into a proposed public-private financing mechanism to support native forestry planting along riparian buffer zones in Ireland. In this proposed programme, funding bodies such as water utilities and dairy processors (which have a vested interest in preserving and improving water quality) join forces with government entities to fund native afforestation in riparian buffer zones. This funding may include a share of the companies' operational revenue as payments for ecosystem services to participating farmers and, in the case of dairy processors, providing more favourable and stable milk pricing and delivery contracts to participating dairy farmers. Integrating financial benefits into existing milk price contracts via price risk management tools and/or forward milk contracting could build trust with participating farmers and allow them to better manage risk and have less uncertainty around milk prices (Wolf, 2012; Loughrey et al., 2015; Giampietri et al., 2020). This approach has the added benefit of normalising and integrating native afforestation as a nature-based solution into the existing dairy industry business model (Iseman and Miralles-Wilhelm, 2021). Given that the results of this study and others (Henchion et al., 2022; Vermunt et al., 2022) find dairy farmers to have a strong productivist mindset, such a scheme would need to support existing farm business practices rather than be a mere substitute for farm product income.

This proposed conservation financing mechanism would operate in keeping with the four key design principles (local, customisable, native, and small scale) identified by this study in several ways. By operating at the local river catchment level rather than at the national scale, farmers, local ecosystem experts, and community members can better craft a flexible and customised solution to the problem of excessive nutrient loads in local surface water. Rather than solely being under the purview and funding authority of the central government, funding would flow from public and private sources (the payors) through a provider of nature-based solutions. In this way, farmers have more flexibility to adapt to the specificities of their local environmental, agricultural, and water quality conditions. By leveraging additional funding support from corporate/private sources, the results-based payments can be more attractive to farmers and allow for native forestry planting rather than the fast growth rates and short harvest cycles of non-native conifer tree species. Furthermore, while current government policies mandate a minimum planting area of one-tenth of a hectare, the proposed mechanism below could allow for smaller planting areas as determined by local environmental conditions. Besides the flow of financial resources (shown below in solid green arrows), information flows (shown below in dashed blue arrows) are key to the proper functioning of such a financial mechanism. Payors such as dairy processors and public funding entities must receive clear information on the programme level results achieved due to their financial contributions. To support this critical information flow, the NBS provider undertakes the monitoring and disbursement activities while biodiversity data is made available to third party verifiers who validate environmental

results. The NBS provider would also be responsible in this scheme for determining environmental appropriateness for afforestation.

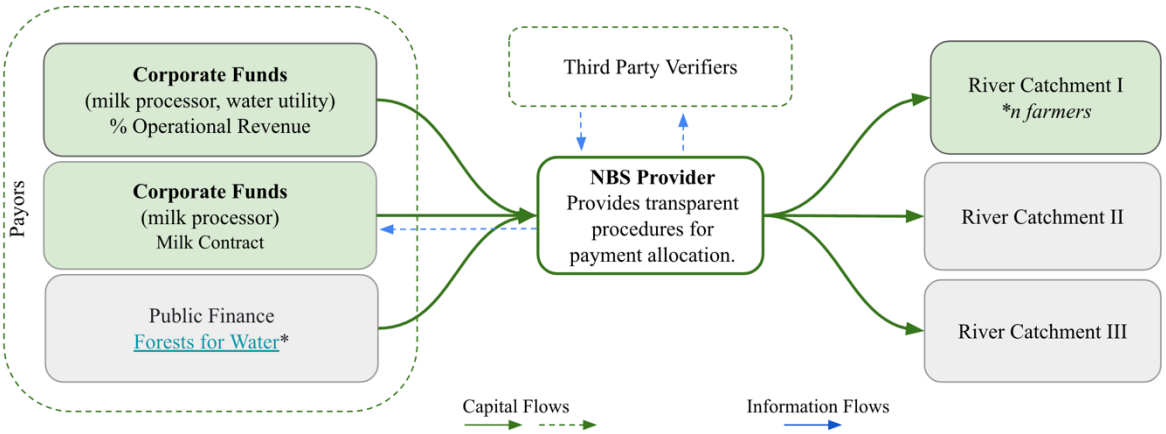


Figure 5 Integrating design principles into a financial instrument. This conceptual map integrates the design principles (l*ocal, customisation, native, small scale*) identified in the Delphi procedure the propose a public-private financing mechanism.

The flows of information and capital shown in Figure 5 above illustrate how a participating milk processor can induce improvements in river quality at a catchment level by supporting their milk suppliers to participate in a results-based payment scheme that promotes the protection and restoration of riverside habitats. In this proposed model, farmer selection is determined using vulnerability mapping and farmers are paid for non-productive investments as well as for results achieved in terms of improved water quality. Corporate funding bodies such as milk processors and/or water utilities are also provided with scientifically validated data on the positive impacts and results achieved through the use of their funds. This provided information can also be verified by third party verifiers if needed for reporting and financing requirements and to demonstrate their contribution to national policy objectives and targets. The proposed private financing mechanism, as illustrated above, draws from the opinions of expert stakeholders which were elicited by the present Delphi study and follow-on discussion group. In doing so, this finance mechanism is based on the key features of a hypothetical local, customisable, and small-scale native forestry funding program which, according to expert stakeholder opinions expressed in the results of this study, is the best way to achieve the native afforestation goals required by Irish governmental policy as well as by environmental necessity. The funding mechanism explained here provides a theoretical and practical framework for the establishment of a real-world pilot programme of results-based-payments which would be the first of its kind in Ireland and would have important implications for the many countries with ambitious environmental afforestation goals in the late transition and post-transition stages of the forest transition model (Mather, 1992).

4. Conclusion

The current study identifies design principles for a novel financing programme for native afforestation. The results establish the need for, feasibility of, and key characteristics of novel native afforestation financing mechanisms. While existing government forestry support programmes have failed to overcome the socioeconomic barriers to native forestry land use change, this research leverages the expertise of stakeholders in this field to identify opportunity pathways to substantially

grow native forestry area in Ireland. These pathways are local, long-term, and work with farmers, not against them. This qualitative research develops the groundwork for empirical research at the local farmer network scale which can contribute to more detailed policy development and costing.

The current study extends the findings of Shipley et al. (2020) and Triana et al. (2022). By convening diverse expert stakeholder groups in a collaborative process, land management programmes can be better designed to support policy goals and the stakeholders impacted by policy change. The participatory approach of Delphi survey and stakeholder discussion support the development of alternative financing programmes to support land-use change for environmental protection. This study builds upon previous research in the Delphi survey and stakeholder engagement realm to incorporate the consensus of expert stakeholders into a workable and realistic policy programme as exemplified by the conservation finance model illustrated in Figure 5 above. The key contribution of this study is the merging of expert stakeholder viewpoints and policy goals to develop a specific mechanism for the achievement of policy objectives. This approach is widely applicable to the development of further agri-environmental funding mechanisms which, because of their novelty, lack deep empirical study, but are critically needed in the short to medium term to mitigate environmental degradation and restore essential ecosystem services. Based on the findings of this study, the establishment of a real-world pilot programme to empirically test the application and impacts of a results-based public/private conservation finance scheme logically follows. Such a future study could accurately measure the participation preferences and willingness to accept (WTA) for local ecosystem services protection. It could also test the impact of public and private funding on actual environmental outcomes in relation to environmental policy goals.

Funding

This work is a completed as part of the project FINIFOR: A Forested Island which is funded by the North-South Research Programme, a collaborative scheme under the Shared Island Fund as part of the Government of Ireland's Shared Island Initiative.

Acknowledgement

The authors gratefully acknowledge the advice and Irish forestry contextual information provided by Mr. John Casey, Forestry Development Officer with the Mallow, County Cork Local Advisory Office of Teagasc, Ireland's Agriculture and Food Development Authority.

Declaration of Competing Interest

None.

CRediT authorship contribution statement

Edward Knapp: Conceptualisation, Formal analysis, Writing - original draft preparation, Writing - reviewing and editing. **Kenneth A. Byrne**: Writing - review and editing, Conceptualisation. **W. George Hutchinson**: Writing - review and editing, Project administration. **Lynn J. Frewer**: Writing - review and editing, Conceptualisation. **John Garvey**: Conceptualisation, Methodology, Supervision, Funding acquisition, Writing - original draft preparation, Writing - reviewing and editing, Project administration.

Data Availability

Data will be made available upon request.

References

Acharya, R. P., Maraseni, T., & Cockfield, G. (2019). Global trend of forest ecosystem services valuation–An analysis of publications. *Ecosystem Services*, 39, 100979.

Ahrens, A., & Lyons, S. (2019). Changes in land cover and urban sprawl in Ireland from a comparative perspective over 1990–2012. *Land*, *8*(1), 16.

Arrow, K.J., Fisher, A.C. (1974). Environmental preservation, uncertainty, and irreversibility. *Q. J. Econ*. 88, 312–319.

Augère-Granier, M. L. (2018). The EU dairy sector: Main features, challenges and prospects. European Commission.

Belton, I., MacDonald, A., Wright, G., & Hamlin, I. (2019). Improving the practical application of the Delphi method in group-based judgment: A six-step prescription for a well-founded and defensible process. *Technological Forecasting and Social Change*, 147, 72-82.

Bernknopf, R.L. and Broadbent, C.D. (2020). Estimating forest sustainability bond prices for natural resource and ecosystem services markets, *Journal of Environmental Investing 10*(1), p.30.

Bord Bia (2024). Irish Sector profiles: Dairy Sector. Irish Food Board. https://www.bordbia.ie/industry/irish-sector-profiles/dairy-sector-profile/

Bradfield, T., R. Butler, T. Hennessy Agricultural policy schemes: European Union's Common Agricultural Policy: Encycl. Dairy Sci. (3rd Ed.) (2021), pp. 688-695, 10.1016/B978-0-12-818766-1.00253-1

Brand, M.W., Seipp, K.Q., Saksa, P., Ulibarri, N., Bomblies, A., Mandle, L., Allaire, M., Wing, O., Tobin-de la Puente, J., Parker, E.A. and Nay, J. (2021). Environmental Impact Bonds: a common framework and looking ahead, *Environmental Research: Infrastructure and Sustainability* 1(2), p.023001.

Brockerhoff, E. G., Barbaro, L., Castagneyrol, B., Forrester, D. I., Gardiner, B., González-Olabarria, J. R., ... & Jactel, H. (2017). Forest biodiversity, ecosystem functioning and the provision of ecosystem services. *Biodiversity and Conservation*, *26*, 3005-3035.

Brumberg, H., Beirne, C., Broadbent, E. N., Zambrano, A. M. A., Zambrano, S. L. A., Gil, C. A. Q., ... & Whitworth, A. (2021). Riparian buffer length is more influential than width on river water quality: A case study in southern Costa Rica. *Journal of environmental management*, *286*, 112132.

Bullock, C., Hawe, J., & Little, D. (2014, December). Realising the ecosystem-service value of native woodland in Ireland. In *New Zealand Journal of Forestry Science* (Vol. 44, pp. 1-10). Springer International Publishing.

Bullock, C. H., O'Callaghan, C., Dhubháin, Á. N., Iwata, Y., O'Donoghue, C., Ryan, M., ... & Kelly-Quinn, M. (2016). A review of the range and value of ecosystem services from Irish forests. *Irish Forestry*.

Carroll, M. S., Ní Dhubháin, Á., & Flint, C. G. (2011). Back where they once belonged? Local response to afforestation in County Kerry, Ireland. *Sociologia Ruralis*, 51(1), 35-53.

Catovsky, S., & Bazzaz, F. A. (2000). Contributions of coniferous and broad-leaved species to temperate forest carbon uptake: a bottom-up approach. *Canadian Journal of Forest Research*, *30*(1), 100-111.

Clark, R., Reed, J., & Sunderland, T. (2018). Bridging funding gaps for climate and sustainable development: Pitfalls, progress and potential of private finance. *Land use policy*, *71*, 335-346.

Climate Action Plan. (2023) Climate Action Plan 2023: Changing Ireland for the Better. Government of Ireland

DAFM, (2020a). Annual Forest Service Statistics. Department of Agriculture, Food and the Marine. Dublin. Forest Service

DAFM, (2020b). Collection: Forest Cover Maps. Department of Agriculture, Food and the Marine.

DAFM (2021). Food Vision 2030 – A World Leader in Sustainable Food Systems. Department of Agriculture, Forestry and the Marine. https://www.gov.ie/en/publication/c73a3-food-vision-2030-a-world-leader-in-sustainable-food-systems/

DAFM. (2022). Forest statistics Ireland 2022. Department of Agriculture, Food and the Marine. Johnstown Castle. July 2022

DAFM. (2023a). Forest statistics Ireland 2023. Department of Agriculture, Food and the Marine. Johnstown Castle. August 2023

DAFM (2023b). Ireland's Forest Strategy (2023 – 2030). Department of Agriculture, Forestry and the Marine https://www.gov.ie/en/publication/89785-irelands-forest-strategy-2023-2030/

DAFM (2023c). Afforestation Scheme 2023-2027 Document. Forestry Division, Department of Agriculture, Forestry and the Marine. Johnstown Castle. October 2023.

Dairy Industry Ireland (2017). Dairy Sustainability Ireland: Improving soil fertility and protecting water quality, A guide for dairy farmers. October 2017. Available at: https://cdn.ibec.ie/-/media/documents/connect-and-learn/industries/food-and-drink/dairy-industry-ireland/dairy-sustainable-ireland-brochure.pdf?rev=38d00917e3ad484fbf9b34253c91a7bf&_ga=2.205155856.1067173422.1713201745-634907688.1712837309.

Devaney, L., & Henchion, M. (2018). Who is a Delphi 'expert'? Reflections on a bioeconomy expert selection procedure from Ireland. *Futures*, 99, 45-55.

Dhubháin, Á. N., Fléchard, M. C., Moloney, R., & O'Connor, D. (2009). Stakeholders' perceptions of forestry in rural areas—two case studies in Ireland. *Land use policy*, *26*(3), 695-703.

Diamond, I. R., Grant, R. C., Feldman, B. M., Pencharz, P. B., Ling, S. C., Moore, A. M., & Wales, P. W. (2014). Defining consensus: a systematic review recommends methodologic criteria for reporting of Delphi studies. *Journal of clinical epidemiology*, *67*(4), 401-409.

Donohoe, H. M., & Needham, R. D. (2009). Moving best practice forward: Delphi characteristics, advantages, potential problems, and solutions. *International Journal of Tourism Research*, 11(5), 415-437.

Duffy, C., O'Donoghue, C., Ryan, M., Styles, D., & Spillane, C. (2020). Afforestation: Replacing livestock emissions with carbon sequestration. *Journal of environmental management*, *264*, 110523.

Ehlers, M. H., Finger, R., El Benni, N., Gocht, A., Sørensen, C. A. G., Gusset, M., ... & Huber, R. (2022). Scenarios for European agricultural policymaking in the era of digitalisation. *Agricultural Systems*, 196, 103318.

Environmental Pillar. (2021). Towards a New Agricultural and Food Policy for Ireland: Recommendations for Government. Environmental Pillar, Stop Climate Chaos, SWAN Sustainable Water Network: Dublin, Ireland.

Ernst and Young (2023). Economic contribution of the dairy processing industry to the Irish economy and the processor's forecasts to 2030. Produced on behalf of Dairy Industry Ireland. October 23, 2023.

EU. (2018). Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU

European Commission. (2020). Farm to Fork Strategy – For a Fair, Healthy and Environmentally-Friendly Food System. European Commission, Brussels.

European Commission. (2021) New EU Forest Strategy for 2030. Brussels, 16.7.2021 COM(2021) 572.

Eurostat. (2018) "Land cover overview by NUTS 2 regions." General and regional statistics: Land cover and land use, landscape (LUCAS)

Eurostat (2021). Production and Utilization of Milk on the Farm - Annual Data [online] Available at: https://ec.europa.eu/eurostat/databrowser/view/apro_mk_farm/default/table? lang¼en. [Accessed 23 February 2021].

Eurostat. (2023) "Forests, forestry and logging: *Forest area in the EU, 2021 (share of forest in total area, %)*". Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Forests,_forestry_and_logging

Ferguson, I., Levetan, L., Crossman, N.D. and Bennett, L.T. (2016). Financial mechanisms to improve the supply of ecosystem services from privately-owned Australian native forests, *Forests 7*(2), p.34.

Forster, E. J., Healey, J. R., Dymond, C., & Styles, D. (2021). Commercial afforestation can deliver effective climate change mitigation under multiple decarbonisation pathways. *Nature communications*, *12*(1), 3831.

Frewer, L.J., Fischer, A.R.H., Wentholt, M.T.A., Marvin, H.J.P., Ooms, B.W., Coles, D. and Rowe, G. (2011). The use of Delphi methodology in agrifood policy development: some lessons learned. *Technological Forecasting and Social Change*, *78*(9), pp.1514-1525.

Garvey, J., Sirr, G., O'Shea, D., & O'Brien, F. (2019). Risk and planning in agriculture: how planning on dairy farms in Ireland is affected by farmers' regulatory focus. *Risk Analysis*, *39*(7), 1491-1502.

Gazheli, A., & Di Corato, L. (2013). Land-use change and solar energy production: a real option approach. *Agricultural Finance Review*, *73*(3), 507-525.

Gelo, D., & Koch, S. (2009). Afforestation subsidy under asymmetric information and transaction cost in developing countries: does rural capital market imperfection matter. *Norwegian University of Life Sciences*.

Giampietri, E., Yu, X., & Trestini, S. (2020). The role of trust and perceived barriers on farmer's intention to adopt risk management tools. *Bio-Based and Applied Economics Journal*, *9*(1), 1-24.

Grisham, T. (2009). The Delphi technique: a method for testing complex and multifaceted topics. *International Journal of Managing Projects in Business*, 2(1), 112-130.

Guo, Y., Liu, C., Liu, H., Chen, K., & He, D. (2023). Financial Literacy, Borrowing Behavior and Rural Households' Income: Evidence from the Collective Forest Area, China. *Sustainability*, 15(2), 1153.

Harrington, F. (2018). *Agricultural land valuation in Ireland: a discounted cash flow approach*. University of Salford (United Kingdom).

Hall, D., Lindsay, S., & Judd, S. (2017). Permanent Forest Bonds: a pioneering environmental impact bond for Aotearoa New Zealand, Victoria University of Wellington, Institute for Governance and Policy Studies, Working Paper 17/01.

Henchion, M. M., Regan, Á., Beecher, M., & Macken-Walsh, Á. (2022). Developing 'smart'dairy farming responsive to farmers and consumer-citizens: A review. *Animals*, *12*(3), 360.

Heneghan, E., Collier, M., & Kelly-Quinn, M. (2021, January). An evaluation of the potential applications of nature-based solutions for water quality protection: Ireland as a case study. In *Biology and Environment: Proceedings of the Royal Irish Academy* (Vol. 121, No. 3, pp. 147-162). Royal Irish Academy.

Hennessy T., Moran B. (2015) Teagasc National Farm Survey 2015 results. https://www.teagasc.ie/media/website/publications/2016/Income-Estimates-2015.pdf.

Henry, C., 1974. Option values in the economics of irreplaceable assets. *Rev. Econ. Stud*. 41, 89–104.

Herrera, D., Cunniff, S., DuPont, C., Cohen, B., Gangi, D., Kar, D., ... & Mountenot, M. (2019). Designing an environmental impact bond for wetland restoration in Louisiana. *Ecosystem services*, *35*, 260-276.

Herron, J., O'Brien, D., & Shalloo, L. (2022). Life cycle assessment of pasture-based dairy production systems: Current and future performance. *Journal of Dairy Science*, *105*(7), 5849-5869.

Hutchinson, G., Scarpa, R., Chilton, S. & Callion, T. M. (2001) Parametric and non-parametric estimates of WTP for forest recreation in Northern Ireland: a multi-site analysis using discrete choice contingent valuation with follow-ups *Journal of Agricultural Economics.* 52, 1, pp. 104-122

Huwyler, F., Käppeli, J., Serafimova, K., Swanson, E., & Tobin, J. (2014). Conservation Finance: Moving beyond donor funding toward an investor-driven approach. *Credit Suisse, WWF, McKinsey & Company*.

Iseman, T., & Miralles-Wilhelm, F. (2021). *Nature-based solutions in agriculture: The case and pathway for adoption*. Virginia. Food & Agriculture Organization and The Nature Conservancy. https://doi.org/10.4060/cb3141en

Kendall, H., Kaptan, G., Stewart, G., Grainger, M., Kuznesof, S., Naughton, P., Clark, B., Hubbard, C., Raley, M., Marvin, H.J. and Frewer, L.J. (2018). Drivers of existing and emerging food safety risks: Expert opinion regarding multiple impacts. *Food Control*, *90*, pp.440-458.

Kenter, J. O., Raymond, C. M., Van Riper, C. J., Azzopardi, E., Brear, M. R., Calcagni, F., ... & Thankappan, S. (2019). Loving the mess: navigating diversity and conflict in social values for sustainability. *Sustainability Science*, 14, 1439-1461.

Kher, V. S., J. Frewer, L., De Jonge, J., Wentholt, M., Howell Davies, O., B. Lucas Luijckx, N., & J. Cnossen, H. (2010). Experts' perspectives on the implementation of traceability in Europe. *British Food Journal*, *112*(3), 261-274.

Knapp, E., & Loughrey, J. (2017). The single farm payment and income risk in Irish farms 2005–2013. *Agricultural and Food Economics*, 5, 1-15.

Krieger, D. J. (2001). Economic value of forest ecosystem services: a review. *The Wilderness Society*

Linstone, H. A., & Turoff, M. (Eds.). (1975). The Delphi method (pp. 3-12). Reading, MA: Addison-Wesley.

Little, C., Cuevas, J. G., Lara, A., Pino, M., & Schoenholtz, S. (2015). Buffer effects of streamside native forests on water provision in watersheds dominated by exotic forest plantations. *Ecohydrology*, *8*(7), 1205-1217.

Loughrey, J., Thorne, F., Kinsella, A., Hennessy, T., O'Donoghue, C., & Vollenweider, X. (2015). Market risk management and the demand for forward contracts among Irish dairy farmers. *International Journal of Agricultural Management*, *4*(4), 173-180.

Lusardi, A., Michaud, P. C., & Mitchell, O. S. (2017). Optimal financial knowledge and wealth inequality. *Journal of political Economy*, 125(2), 431-477.

Mack, G., El Benni, N., Spörri, M., Huguenin-Elie, O., Tindale, S., Hunter, E., Newell Price, P. and Frewer, L.J., 2023. Perceived feasibility of sward management options in permanent grassland of Alpine regions and expected effects on delivery of ecosystem services. *Environment, Development and Sustainability*, pp.1-23.

Madeira, L. and Gartner, T. (2018). Forest Resilience Bond Sparks Innovative Collaborations Between Water Utilities and Wide-Ranging Stakeholders, *Journal of the American Water Works Association, 110*(6).

Madsen, L. M. (2003). New woodlands in Denmark: the role of private landowners. *Urban Forestry & Urban Greening*, *1*(3), 185-195.

Mather, A. S. (1992). The forest transition. *Area*, 367-379.

McCracken, E. (1971). The Irish woods since Tudor times. Distribution and exploitation. *The Irish woods since Tudor times. Distribution and exploitation.*

McMahon, P., (2023) Island of Woods. New Island Books. Dublin

Meli, P., Rey-Benayas, J. M., & Brancalion, P. H. (2019). Balancing land sharing and sparing approaches to promote forest and landscape restoration in agricultural landscapes: Land approaches for forest landscape restoration. *Perspectives in Ecology and Conservation*, *17*(4), 201-205.

Millennium ecosystem assessment, M. E. A. (2005). Ecosystems and human well-being (Vol. 5, p. 563). Washington, DC: Island press.

Minister for Lands and Agriculture. (1928). Dail Eireann, Volume 23, 3rd May 1928.

Mori, A. S., Lertzman, K. P., & Gustafsson, L. (2017). Biodiversity and ecosystem services in forest ecosystems: a research agenda for applied forest ecology. *Journal of Applied Ecology*, 54(1), 12-27.

Neeson, E., (1991). A History of Irish Forestry. The Department of Energy and the Lilliput Press, Dublin, Ireland.

Niedzwiedz, A., Roman-Amat, B., & Butault, J. P. (2011). Première approche de la valeur ajoutée produite par l'amont du secteur forestier en France. *Revue forestière française*, *63*(4), 435-444.

O'Carroll, N. (2004). Forestry in Ireland–a concise history. COFORD, National Council for Forest Research and Development. Dublin.

O'Driscoll, C. (2023). Urban sprawl: land-use, travel behaviours, and emissions in Ireland. CORA, Cork Open Research Archive. https://cora.ucc.ie/items/110a05f4-201f-4e5b-b0aa-0be716a1c134

Origin Green (2024). Origin Green Ireland: Dairy. Available at: https://www.origingreen.ie/who-is-involved/manufacturers/dairy/

Phalan, B. T. (2018). What have we learned from the land sparing-sharing model?. *Sustainability*, *10*(6), 1760.

Piffer, P. R., Tambosi, L. R., Ferraz, S. F. D. B., Metzger, J. P., & Uriarte, M. (2021). Native forest cover safeguards stream water quality under a changing climate. *Ecological Applications*, *31*(7), e02414.

Quinn, J. M., & Stroud, M. J. (2002). Water quality and sediment and nutrient export from New Zealand hill-land catchments of contrasting land use. *New Zealand journal of marine and freshwater research*, *36*(2), 409-429.

Raum, S. (2017). The ecosystem approach, ecosystem services and established forestry policy approaches in the United Kingdom. *Land Use Policy*, *64*, 282-291.

Ryan, M., O'Donoghue, C., Hynes, S., & Jin, Y. (2022). Understanding planting preferences–A case-study of the afforestation choices of farmers in Ireland. *Land Use Policy,* 115, 105982.

Ryan, M., O'Donoghue, C., Phillips, H., (2016). Modelling financially optimal afforestation and forest management scenarios using a bio-economic model. *Open J. For.* 6,19–38.

Ryan, M., & O'Donoghue, C. (2016). Socio-economic drivers of farm afforestation decision-making. *Irish Forestry*.

Scarpa, R., Chilton, S. M., Hutchinson, G. & Buongiorno, J., May (2000). Valuing the recreational benefits from the creation of nature reserves in Irish forests. *Ecological Economics*. 33, 2, p. 237-250.

Scarsbrook, M. R., & Halliday, J. (1999). Transition from pasture to native forest land-use along stream continua: Effects on stream ecosystems and implications for restoration. *New Zealand Journal of Marine and Freshwater Research*, *33*(2), 293-310.

Shipley, N. J., Johnson, D. N., van Riper, C. J., Stewart, W. P., Chu, M. L., Suski, C. D., ... & Shew, J. J. (2020). A deliberative research approach to valuing agro-ecosystem services in a worked landscape. *Ecosystem Services*, 42, 101083.

Song, B., Robinson, G. M., & Bardsley, D. K. (2020). Measuring multifunctional agricultural landscapes. Land, 9(8), 260.

Strange, N., Jacobsen, J. B., & Thorsen, B. J. (2019). Afforestation as a real option with joint production of environmental services. *Forest Policy and Economics*, 104, 146-156.

Tan, J., Cai, D., Han, K., & Zhou, K. (2022). Understanding peasant household's land transfer decision-making: A perspective of financial literacy. *Land Use Policy*, *119*, 106189.

Teagasc. (2021). Forest Carbon Tool. Teagasc, Forest Environmental Research and Services (FERS) Limited and the Department of Agriculture Food and the Marine (DAFM).

Thees, O., Erni, M., Lemm, R., Stadelmann, G., & Zenner, E. K. (2020). Future potentials of sustainable wood fuel from forests in Switzerland. *Biomass and Bioenergy*, *141*, 105647.

Thompson, B.S., 2023, Impact investing in biodiversity conservation with bonds: An analysis of financial and environmental risk, *Business Strategy and the Environment 32*(1), pp.353-368.

Thorsen, B.J., (1999). Afforestation as a real option: some policy implications. *For. Sci.* 45 (2), 171–178.

Triana, J. S. A., Chu, M. L., Shipley, N. J., Van Riper, C. J., Stewart, W. P., & Suski, C. D. (2022). A decision-making framework for evaluating environmental tradeoffs in enhancing ecosystem services across complex agricultural landscapes. *Journal of Environmental Management*, 314, 115077.

UN. (2023). Making sense of Article 2.1(c): What role for private finance in achieving climate goals? United Nations publication issued by the United Nations Conference on Trade and Development. eISBN: 978-92-1-358732-4

USDA (2024). U.S. Department of Agriculture, Farm Service Agency. Conservation Reserve Program (CRP): About the Conservation Reserve Program (CRP). Available at: https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index

Vermunt, D. A., Wojtynia, N., Hekkert, M. P., Van Dijk, J., Verburg, R., Verweij, P. A., ... & Runhaar, H. (2022). Five mechanisms blocking the transition towards 'nature-inclusive'agriculture: a systemic analysis of Dutch dairy farming. *Agricultural Systems*, *195*, 103280.

Walters, D., Kotze, D. C., Rebelo, A., Pretorius, L., Job, N., Lagesse, J. V., ... & Cowden, C. (2021). Validation of a rapid wetland ecosystem services assessment technique using the Delphi method. *Ecological Indicators*, 125, 107511.

Witing, F., Forio, M. A. E., Burdon, F. J., Mckie, B., Goethals, P., Strauch, M., & Volk, M. (2022). Riparian reforestation on the landscape scale: Navigating trade-offs among agricultural production, ecosystem functioning and biodiversity. *Journal of Applied Ecology*, *59*(6), 1456-1471.

Waters of LIFE (2024). Waters of LIFE About: Waters of LIFE approach. Available at: https://www.watersoflife.ie/about/

Wiemers, E., Behan, J., 2004. Farm forestry investment in Ireland under uncertainty. *Econ. Soc. Rev. Econ. Soc. Stud*. 35 (3), 305–320.

Wolf, C. A. (2012). Dairy farmer use of price risk management tools. *Journal of dairy science*, *95*(7), 4176-4183.

Wolf, I. D., Sobhani, P., & Esmaeilzadeh, H. (2023). Assessing Changes in Land Use/Land Cover and Ecological Risk to Conserve Protected Areas in Urban–Rural Contexts. *Land*, 12(1), 231.

Yemshanov, D., McCarney, G. R., Hauer, G., Luckert, M. M., Unterschultz, J., & McKenney, D. W. (2015). A real options-net present value approach to assessing land use change: a case study of afforestation in Canada. *Forest Policy and Economics*, *50*, 327-336.

Źróbek-Różańska, A., Nowak, A., Nowak, M., & Źróbek, S. (2014). Financial dilemmas associated with the afforestation of low-productivity farmland in Poland. *Forests*, *5*(11), 2846-2864.