An economic appraisal of the implementation of Short Rotation Coppice willow for the mitigation of the effects of Hydrologically Sensitive Areas on water pollution

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Contents

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Executive Summary:

There are many circumstances, opportunities and agricultural scenarios whereby SRC willow could be integrated into different farming enterprises however, to develop an understanding of how the economics look, this report compares the economic impacts of introducing a Short Rotation Coppice (SRC) willow buffer area within a suckler beef system. The SRC provides an additional enterprise to the farm, as well as providing a public good in the form of an ecosystem service [reduced phosphate run-off to watercourses]. SRC willow offers many other ecosystem services such as improvements in soil carbon & biodiversity.

This report documents how the Phosphorus and Agricultural Resilience Model (PhARM) has been used to compare the optimal amount of land to convert to SRC willow across a range of different stocking densities and prices. A benefit of implementing this type of model is the ability to systematically explore the importance of farm and market conditions when changing farm management to introduce areas of SRC willow (which will have the effect of reducing nutrient run-off). The example provided here considers if and by how much farm income may be improved if some land is removed from grass production and placed into SRC willow buffer strips and biofiltration blocks. This is accomplished by varying the intensity of beef production on the available land base as well as the expected return from adding the willow enterprise.

1. Introduction

Since about the 1970s, energy crops such as Short Rotation Coppice (SRC) willow have been considered a viable option to provide some energy security where no fossil fuel reserves existed. However, despite historical financial support for planting (Biomass Crop Establishment Grants (NI and RoI) and biomass challenge fund (NI)), the planting rates remained relatively low. This was for many potential reasons, however importantly, no long-term sector confidence materialised from any policy initiatives and as such farmers were reluctant to commit to a scheme that required at least a 5-year period of crop maintenance but also for a number of other reasons … The following concerns existed then and are still prevalent today….

- Crop establishment difficulties (it is an unknown crop, requires a lot of specialised knowledge and advice which isn't always readily available).
- Lack of Infrastructure
- Lack of Processing
- Lack of Market
- Lack of advice and knowledgeable consultancy
- No indication that the market would have longevity (potentially supported by short term incentives, no long-term policy).
- No supply chain for crop management
- No real precedent of willow growing to follow.
- Poor economics (in comparison to other pursuits such as Dairy)
- Regulatory Issues with waste recycling to biomass crops such as SRC willow Crops

1.1. Biomass Crop diversification in Farming

The main factor which became clearly obvious during the running of the Interreg VA EU-CatchmentCARE project was that competition from other agricultural enterprises effectively made the idea of growing SRC willow planting far less appealing to the farmer. The evidence from speaking to a multitude of farmers and landowners has illustrated the following reasons as to why not to diversify into biomass crops; to any degree whatsoever.

- Milk prices currently around £0.45 / litre – No way biomass crops can compete.
- No interest in land use Change - tradition
- Immaturity of the biomass sector
- Limited markets
- Disparate contractor access
- Stigma of renewable energy incentives and policy errors
- Unknowns (GHG, carbon, water quality, polluter pays)
- Perceived risk of trying something new when contemporaries will consider it madness!

1.2. Developing policy

There are however a number of recent policy initiatives and strategies which could point towards the incorporation of Biomass crops within our agricultural setting. The Net Zero Strategy sets out an ambitious plan to achieve its Net Zero targets by 2050[i]. In the UK there is wide-spread acceptance that biomass, including bioenergy with Carbon Capture & Storage (CSS) has a key role to play in achieving net Zero[ii]. The question is essentially where and how biomass crops are best used to deliver on these targets – whether it is for generating, electricity, heat, biofuels or other unrelated energy purposes and carbon resources. Likewise, Renewable Energy Ireland and the Irish Bioenergy Association published "40by30", a roadmap to an Ireland where 40% of required heat can come from renewables by 2030.

Other initiatives such as the "*2021 – International Energy Agency (IEA) - Net Zero by 2050 - A Roadmap for the Global Energy Sector*" and the "*2021 - UK 6th Carbon Budget – CCC – Key Recommendations*" clearly advise government to develop a far greater level of biomass crop production.

1.3. The N.Ireland Sustainable Agri-land Management Strategy

A stroke of foresight and recognition can be aligned to this strategy published in 2016 where the N.Ireland government was advised (Recommendation 3c) to target water quality interventions on at least 4,000 ha (Point Source & Diffuse). The EU-CatchmentCARE project has developed further the demonstration and evidence base of how SRC willow can help contribute to agricultural sustainability in this regard.

1.4. The question of SRC Willow economics?

However, a big question naturally presents itself - Can the partial agricultural diversification of SRC willow in intensive livestock agriculture ever be economically viable? Can the devotion of certain farm areas, for improved environmental good, align with enhanced or steady farm incomes, and if so to what extent? Can the implementation of a crop which offers a range of benefits (such as improved soil carbon, GHG removal, improved water quality, improved biodiversity, employment and a diversified product) ever become attractive economically?
The economics of growing SRC willow has been one of the main reasons why the crop has not taken off as a viable agricultural diversification option.

2. Costs and economics of biomass crops

Currently, the only real market for SRC willow is for energy; a direct replacement for heat and power delivered from fossil fuels such as coal, oil and gas. This report is based on current approximations of the costs and prices from the biomass market today.

Willow can be grown either for self-supply or for sale to a contractor who may buy the crop directly from the field, harvest it and take it away. Prices at the time of this report are around £10 to £15 per fresh tonne depending on factors such as the location, crop age and proximity to a customer. This return is unlikely to attract farmers to plant willow as it would amount to a return of around £200 to £300 / year. In Great Britain these values are significantly more as a result of local biomass users which include power stations and industry with significant Combined Heat and Power Needs[iii] [iv]. Farm gate prices of between £15 to £29 per wet tonne are usual however this is recognised in the sector as being too low; especially if the value of harvested forestry thinnings and off cuts is taken into comparative consideration. Returns need to be more than this and if not by the direct value of the chip, then supported by grant aid or agricultural subsidy as a service for public goods. For these reasons, fresh wood chip prices in this analysis start at £30/tonne with increases. Of course, far higher prices can be achieved for selling of woodchip if processed to some degree. In Ireland, wood chip currently sells for between £145 and £165 / tonne at 25% MC.

This analysis examines a range of wood chip prices from between £30 and £70/tonne.

2.1. Establishment costs

When establishing willow, the costs of land preparation, planting material and the actual planting along with the necessary weed control pre and post planting and cut-back, must all be considered. There may be other costs to consider such as fencing for rabbits and unexpected weather effects (flood, drought) to contend with however it is generally considered that, in Ireland, once the crop is well established, there is every reason to expect on-going harvests for 25 to 30 years. The cost of establishment is currently considered to be in the region of €2,600 (£2,300) per ha.

To estimate this cost on a 'per tonne basis' the following assumptions have been made and calculated on a dry tonne basis. (N.B. A dry tonne is 0%MC. In reality this will never exist in biomass production however for cost calculation purposes, it is valuable as a common denominator to keep all costs consistent).

- 25 year crop existence giving 8, 3-year harvests
- Average yield 10 dry tonnes / ha / y (or approx. 20 fresh tonnes/ha/y which builds in some safety buffer)
- Dry tonnes produced over lifetime (8 harvests x 30 tonnes/ha) = 240 dry tonnes
- Harvest costs = £700/ha
- Establishment per dry tonne = £2,300/210 = £11 / tonne
- Termination costs for grubbing out at the end of the activity = £99/ha

For self-supply, other requirements must also be factored in such as harvesting, drying, storage and miscellaneous costs such as loading floors and bays and management around the farm.

2.2. Harvesting costs

Although there are a number of harvesting methods, only chip harvesting exists in Ireland; Whole-stem, bale and billet harvesting do not currently exist as harvesting options. Harvesting costs can be applied in a number of ways. By ha harvested or by tonne of fresh chip harvested. The cost of harvesting can be in the region of £12.50/ fresh tonne or around £750/ha. This will depend on a number of factors such as area to be harvested, proximity to contractor, age and size of the plantation, land and weather conditions. This cost would equate to around £25 per dry tonne.

2.3. Drying / processing costs

Following harvest, the chip must be processed which will entail drying and potentially grading. The requirement for this will depend on the needs of the final customer (chip quality standard) and whether the chip needs to be stored. The

cost for this can add approximately a further £15/ dry tonne.

2.4. Haulage Costs

At the time of this report, haulage costs are around £20 per dry tonne within an approximate 70 mile distance. Normally this is done by moving floor trailer capable of carrying 15 to 20 dry tonnes in a load however can also be by farm trailer if distances make economic sense.

2.5. Summary costs

The above costs will therefore amount to…

Establishment	£11 / dry tonne
Harvesting	£25 / dry tonne
Processing / drying	£15 / dry tonne
Miscellaneous	£10 / dry tonne
Total (*exc haulage*)	**£61 / dry tonne**

At the time of writing this report, SRC willow woodchip is selling at around £150/tonne at 20% MC ex yard which will cover all supplier costs and make a profit. At this cost, heat from willow wood chip will be less than 50% than that of heat from oil or natural gas, even taking into consideration the efficiency losses from wood chip systems.

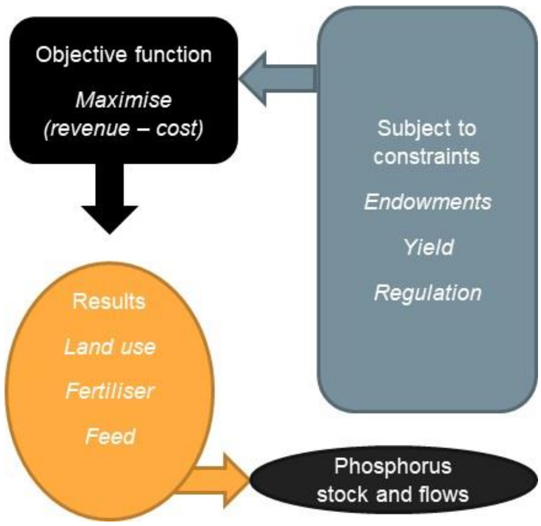
3. PhARM Model Introduction

The objective of the Phosphorus and Agricultural Resilience Model (PhARM) is to provide an interface between economic and biophysical relationships that can be used to illustrate and explore key interactions and trade-offs mitigating diffuse pollution from agricultural activity. The incorporation of SRC willow in this context is focused on the protection of water quality from run-off of phosphorus however it has an added benefit being that the biomass crop will have an end value either as a low carbon fuel to displace fossil fuels, or as an alternative carbon resource for other end uses. This report documents how the PhARM[1] model has been used to compare the economic impacts of implementing targeted SRC willow areas within a suckler beef system. The analysis is based on a static comparison across different stocking densities and prices.

A benefit of implementing this type of model is the ability to solve for the amount of land that can be converted to SRC willow (which will have the effect of reducing nutrient run-off) that maximises the expected market return from both the suckler and willow enterprises jointly. In this case, the farm has the option to shift land from grass production to SRC willow buffer strips and SRC willow biofiltration blocks. The decision of how much land (if any) is allocated to SRC willow is compared across different stocking intensities, and the assumed market value of willow biomass.

4. Overview

The model solves for the amount of land in SRC willow that is optimal for the farm, defined as maximising revenues (from both beef and willow production) less major costs (feed, fertiliser, willow establishment and harvest). The modelled farm may place up to 5% of the available 50 hectares of grassland into willow production. The stocking density of the beef enterprise, and price received for the woodchip from the willow enterprise, are varied over a range of values. Stocking density is important because it determines whether converting grassland to willow carries an opportunity cost for the beef enterprise. This opportunity cost could be additional fertiliser (to boost production on remaining grassland) or feed (to replace grass in the diet). The price the farmer receives for woodchip is important because it determines the net return per area of SRC willow.



[1] Full model documentation including all equations and parameter assumptions is available by request (erin.sherry@afbini.gov.uk)

5. A shadow price for phosphate loss to water avoided

At the start of the period analysed, land is allocated into one of two categories, temporary or permanent grassland. Land is moved into a SRC willow buffer strip if the net revenue from placing a willow enterprise on that land exceeds the opportunity cost of removing that land from the beef enterprise. The economic impact to the farm per unit of phosphate loss avoided can be calculated by dividing the difference in farm net revenue (receipts less costs for both beef and willow) by the difference in expected phosphate run-off (without and with the willow buffer).

The phosphate loss to water can be mitigated by the buffer strip, as some of the phosphate loss from grassland will be 'taken up' by vegetation growth by the SRC willow buffer zone.

These calculations are however an underestimation of reduced phosphate run-off given the understanding of how SRC willow can decrease the actual overland runoff of nutrient and as such, it is not just the crop uptake of phosphate which contributes to the public good of reduced nutrient runoff. The SRC willow area serves to reduce overland flow by the introduction of surface roughness, increased hydraulic conductivity and soil percolation as well as increasing the whole transpiration cycle because of the extensive root system, given the high water requirements of willow[v].

6. Main assumptions applied

The main assumptions applied in the analysis relating to the representative farm are provided in Table 1. The following SRC willow enterprise parameters have been introduced into this suckler beef enterprise model, Table 2.

Table 1 – Beef enterprise assumptions

Parameter	Description	Unit	Assumption
$pcalf$	Price of weaned calf	£ per head	£600
$pfeed$	Price of feed	£ per tonne	£315
pP	Price chemical phosphate	£ per kg phosphate	£0.318
pN	Price chemical nitrogen	£ per kg nitrogen	£0.246
$plime$	Price lime	£ per kg	£0.02
$hcows$	Number of sucker cows	cow	60, 63, 64, 65, 66 & 67
al=$pasture$	Land in permanent pasture	Hectares	45
al=$temporary$	Land in temporary grassland	Hectares	5
ml	Percent of sward in clover	Between 0 and 100	5% (pasture) 20% (temporary)
$slOlsen$	Olsen P from soil test	Mg/litre	30 (pasture) 25 (temporary)
r	Region	Categorical (index)	Northern Ireland
s	Soil type	Categorical (index)	Brown Earth

Table 2 – SRC willow enterprise assumptions

Parameter	Description	Value
price_woodchip	expected price per wet tonne of woodchip	Varied between £30-£70 per wet tonne
establishment	seedling and other costs per hectare	£2293
termination	cost per hectare to mulch at end of life cycle	£99
harvest	cost per hectare to harvest direct chip	£700
years_contract	years contract active costs are spread	20
years_harvest	frequency of harvesting	3
willow_capture	P2O5 offtake per hectare of willow per year	55
willow_yield_annual	annual yield of willow wet tonnes per year	20
annual_costs	costs spread over life of contract	

7. Structural parameters

7.1. Introduction of SRC willow

The model is run for 8 different stocking densities, starting from 63 suckler cows (about 1.2 livestock units per hectare including followers) increasing by 1 head up to 70 (about 1.33 livestock units per hectare). Six different prices for the SRC biomass are assumed from £0 to £70/tonne giving a total of 48 solution sets. For each stocking/willow price combination, an SRC willow buffer area of up to a maximum of 5% of the land endowment (2.5ha in a 50 ha) can replace grassland previously used for beef production.

The farm gross margin for each scenario is shown in Figure 2. Given the characteristics of the suckler enterprise, gross margin is highest between 1.29 and 1.33 livestock units per hectare. Stocking beyond this, reduces the gross margin that can be achieved, and carries a higher opportunity cost of converting some grassland into a buffer zone. Stocking below that rate would indicate an opportunity cost for increase in stocking and production of weaned calf.

At higher stocking rates, there is no annual gross margin improvement as a result of implementing SRC buffer zones, even at the maximum assumed price of £70 per wet tonne. At stocking density 1.33 and above, fertiliser limits have already been reached, so the reduction in grassland area to the willow buffer area, and subsequent lower amount of grass available, is compensated for with purchased feed. This means, although the fertiliser bill decreases, the feed bill increases from £1,500 up to £2,344 in the case of a 5% willow buffer zone. The combined impact of these cost changes, assuming the number of cows remains the same, and the stocking density changes in response to the buffer, has a relatively small impact on gross margin in the case grass production can be increased, and a more pronounced impact in the case additional feed must be purchased to replace the foregone grass production.

Price per wet tonne	£ -	£ 30	£ 40	£ 50	£ 60	£ 70
Stocking density (livestock units per hectare)						
1.20	0	2.5	2.5	2.5	2.5	2.5
1.22	0	2.5	2.5	2.5	2.5	2.5
1.24	0	2.5	2.5	2.5	2.5	2.5
1.25	0	1.8	2.4	2.4	2.4	2.4
1.27	0	1.0	1.6	1.6	1.6	1.6
1.29	0	0.2	0.9	0.9	0.9	0.9
1.31	0	0.0	0.1	0.1	0.1	0.1
1.33	0	0	0	0	0	0

Figure 1 - Hectares planted in buffer strip (maximum 5% of land area so 2.5 hectares)

Price per wet tonne	£ -	£ 30	£ 40	£ 50	£ 60	£ 70
Stocking density (livestock units per hectare)						
1.20	£ 30,385	£ 30,868	£ 31,368	£ 31,868	£ 32,368	£ 32,868
1.22	£ 30,843	£ 31,204	£ 31,704	£ 32,204	£ 32,704	£ 33,204
1.24	£ 31,302	£ 31,540	£ 32,040	£ 32,540	£ 33,040	£ 33,540
1.25	£ 31,714	£ 31,828	£ 32,293	£ 32,767	£ 33,241	£ 33,714
1.27	£ 32,051	£ 32,115	£ 32,430	£ 32,753	£ 33,075	£ 33,398
1.29	£ 32,387	£ 32,403	£ 32,566	£ 32,738	£ 32,910	£ 33,082
1.31	£ 32,683	£ 32,683	£ 32,703	£ 32,724	£ 32,745	£ 32,766
1.33	£ 32,209	£ 32,209	£ 32,209	£ 32,209	£ 32,209	£ 32,209

Figure 2 - Expected gross annual margin (£)

7.2. Effect of changing SRC willow price

When the value of the SRC willow biomass is taken into consideration, this naturally has a more profound effect on gross margin as the value of the biomass increases. There have been illustrations of this during 2022 when energy costs increased and as a result, improved prices for wood energy could be achieved in the market increasing the value of the raw product (wet wood chip). A feature of Net Zero 2050, Climate Change Strategies and Government policies to achieve these goals could be that these values improve over the coming years (or indeed due to further energy price inflation for reasons such as geo-political unrest).

It is interesting to note that at a stocking density of 1.25 (66 cows per ha), a greater annual gross margin could be achieved with a Biomass price of £50 / tonne than a stocking rate of 1.31 (69 units per ha) which illustrated the highest return for the enterprise with zero willow buffer zone. This pattern naturally improves as biomass prices improve.

At £40 a tonne of biomass, the return from the willow becomes greater than the additional fertiliser (in this case phosphate) purchased to increase the yield on the silage land to reach maximum yield (12.46 tonnes dm/y). In other words, the farmer can continue to increase grass production on the remaining land to compensate replacing up to the 0.1 ha of land into willow.

However, if the farmer plants more than the 0.1 has in willow, he will need to replace that foregone grass with concentrates. Based on our assumptions of the price of concentrates, even at £70 per wet tonne, it would still cost more to replace any grassland with concentrates. So, this result will be sensitive to the relative prices of concentrates, and willow inputs and outputs.

7.3. Phosphate Loss

Furthermore, not only can the reduction in stocking density and introduction of SRC buffer zones improve gross annual margin, but as a result, it will improve P runoff (the original intention of integrating SRC willow within the intensive agricultural landscape)[vi]. Although the actual reduction in P runoff has not been used in the economic calculations in this model, the clear benefit and public good will have a value. It is clear from Figure 3 that the financially supported reduction in livestock intensity from 1.31 to 1.25, does have the effect of reducing P export from over 1000 kg phosphate to 950 kg phosphate. The SRC willow biofiltration effects however will reduce this even more, given that it will be planted within areas of hydrological connectivity as riparian protection or biofiltration blocks[vii]. As the stocking rate increases and the SRC willow protection area decreases, P export increases.

Price per wet tonne Stocking density (livestock units per hectare)	£ -	£ 30	£ 40	£ 50	£ 60	£ 70
1.20	692	583	583	583	583	583
1.22	696	681	681	681	681	681
1.24	700	780	780	780	780	780
1.25	740	837	896	896	896	896
1.27	839	894	953	953	953	953
1.29	937	951	1,009	1,009	1,009	1,009
1.31	1,056	1,056	1,066	1,066	1,066	1,066
1.33	1,078	1,078	1,078	1,078	1,078	1,078

Figure 3. Expected farm runoff (kilograms P2O5)

8. Conclusion

The PhARM provides a framework to carry out comparative static analysis across different types of suckler enterprises to systematically understand how alternative approaches to reduce phosphate loss to water will impact farm income in different contexts.

To illustrate this, a scenario of implementing a SRC willow buffer strip on a suckler enterprise, and varying the livestock units, reveals that the impacts to income and expected phosphate loss are sensitive to stocking density (holding other farm characteristics constant) and willow area planted. Depending on the expected market price of the SRC willow biomass, Gross annual farm margins can be improved, even at lower stocking densities (1.31 to 1.25 LU/ha). These plantations will lead to reduced Phosphate export from the farm holding which will also have a value of public good which is still to be valued. It is expected that water quality protection strategies such as the planting of SRC willow will ultimately be promoted through environmental schemes or governmental biomass strategies.

Appendix 1

EU-CatchmentCARE – SRC integrated with Livestock Agriculture

EU CatchmentCARE[viii] is an EU-funded project that aims to improve freshwater quality within the Northwestern and Neagh Bann international river basins. The project is focussed across three cross-border catchments, the Arney, Blackwater and Finn. The aims are being achieved through development of water quality improvement projects and installation of groundwater monitoring stations across the region. The project overall is grounded in the Water Framework Directive (WFD).

One part of the project was to develop a platform and demonstrate how the implementation of SRC willow in an intensive livestock setting could be used for agricultural diversification and environmental protection. This has led to much engagement and knowledge dissemination largely focussed on the implementation on one of the sub catchments within the AFBI Hillsborough farmed estate.

Water Quality Protection - integrated livestock farming

It has long been considered that SRC willow could serve a very functional and appropriate purpose in NI[ix] and RoI by integrating its establishment with intensive livestock agriculture in such a way that it could provide an environmental protection and diversification opportunity. The EU-CatchmentCare project has afforded the opportunity to explore this via a proof-of-concept and help illustrate this.

Figure 1. SRC willow biofiltration block (approx. 1.9 ha) within a 22ha sub-catchment.

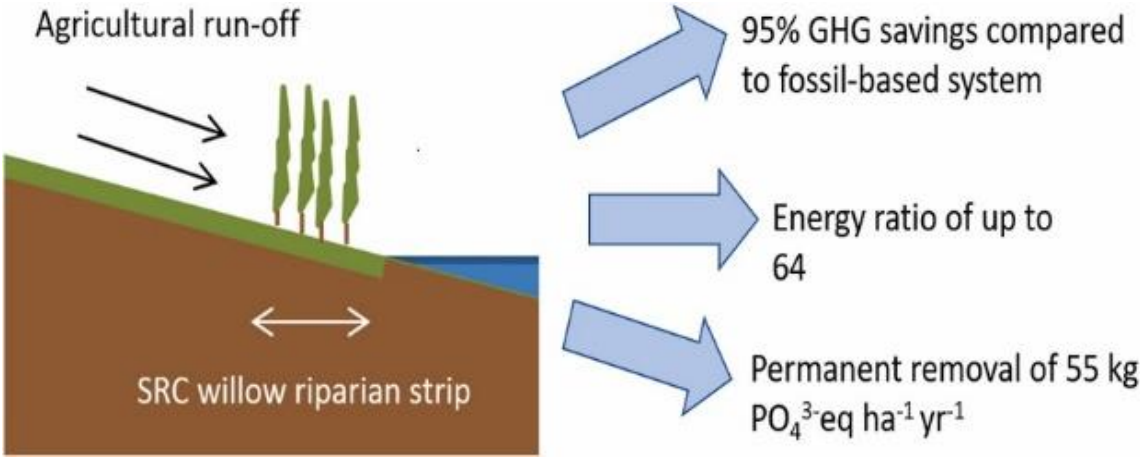


Figure 2. Methodology of environmental protection and GHG substitution[x]

Furthermore, given the concern than any diversification to biomass crops such as SRC willow could bring about a reduction in agricultural output (Dairy, Beef, Sheep, cereals), it is important that this platform is used to demonstrate as far as possible that such progressive environmental interventions can actually improve agriculture in terms of water quality, economics, carbon, biodiversity and improved Life-Cycle Analysis. Through the sister EU-Bryden Centre project, an LCA has been completed using an Irish dairy farm case study in exactly this way.

SRC Willow interventions in intensive livestock farming.

It has been modelled that on a typical dairy farm, SRC willow biofiltration blocks can reduce total phosphorus discharge by 9% and total CO_2eq emissions could be reduced by 16.5% if energy from the willow displaces fossil fuels; along with minimal effect on milk production[xi].

Water Quality & Buffer strips / biofiltration Blocks

Eutrophication of freshwater remains a significant environmental issue within Europe, with agriculture identified as a primary source of phosphorus (P) in many countries. In 2018 the EU average for surface water bodies achieving 'Good or Better' ecological status, as defined by the Water Framework Directive (WFD), was only 40%. Despite a significant investment in mitigation strategies, in many cases, the reduction in P export from agricultural systems have been insufficient to meet the targets of the EU Water Framework Directive. There remain significant challenges in balancing the often-competing objectives of agricultural intensification and environmental protection however one such measure could be the use of SRC willow planted in buffer strips or biofiltration blocks along at the edge of fields or in riparian areas.

Life Cycle Assessment

A life Cycle Assessment (LCA) or Life Cycle Analysis is a complete, 'cradle to grave' analysis of the sum of all the potential environmental impacts of products or services during the full life-cycle period. All environmental impacts must be considered which accounted for which normally include production, manufacture, transportation, distribution, maintenance, operation and finally recycling, disposal or other end-of life activities. There is a lot in the literature about the environmental benefits of willow in displacing GHGs as a fossil fuel displacement however these are almost fully based on plantations for carbon resource bioenergy instead of smaller targeted and purpose grown areas for integration within agriculture.

As such the LCA calculations will be completely different due to differences in harvesting, establishment, fertilisation, management and potentially even others.

A typical biomass buffer strip – Energy Flows

The Catchment Care SRC platform willow harvesting areas demonstrated a yield of 13.3 tonnes of dry matter/ha/year. These harvests are at the higher end of yield records and probably down to 1 of several reasons.

- The willow varieties planted are more recent and higher yielding clones than those which would have been planted 20+ years ago.
- The willows are at the start of their yield phase (some other clones naturally reduce in survival or yield have a during of growth and harvesting[xii].
- Willows in riparian biofiltration areas will, by definition, be continually fertilised with water and nutrient run-off.

This harvest therefore equates to an energy production of 67,000 kWh/ha/y (@ 5,000 kWh / tonne). A number of indicators suggest that a 5% land conversion is possible and if this were the case with dairy farms, this would give an energy production equivalent of 3,300 kWh/ha/y. The processing requirements and energy conversion efficiencies used in Bryden Centre LCA analysis, would suggest a resulting energy conversion of 90% (combined heat and power) or 3,000 kWh/ha/y which could be used for process heating & cooling and other uses such as pumping, lighting and space heating.

A typical biomass buffer strip – Nutrient Flows

Dairy farms in Ireland have a Phosphorus surplus of 9.8 kg P /ha/y[xiii] and this is considered to be even higher in N.Ireland. There is also a significant amount of Nitrogen leached from farms. Phosphorus residing within an agricultural system will do several things which include mainly adhering and binding to soil particles but also running through surface and near surface soil layers to such a point where a % may leach from the system in to receiving environmental waters. It is targeting these zones of hydrological connectivity where the most beneficial effect of the SRC willow interventions and be realised. There is much data on P removal rates however a value of 1.3 g P/kg dry matter was realised from the EU-CatchmentCare work which aligns well with previous data published by AFBI where P removal from different willow varies ranged from 1.08 to 1.51 and averaging 1.26 g P/kg dm[xiv]. at 13.3 tonnes/ha/year. Converting this to a SRC willow area result in approximately 9% of P taken up by the SRC willow and permanently prevented from leaching from the system. Further work (unpublished) in indicating that up to 30% of P can be retained by the SRC willow intervention. Apart of P uptake by the crop itself, which is then removed at harvest, it is postulated that P is also managed by the increase in hydrological conductivity and permeability and reduction in volumetric flows. P is therefore retained by the soil / plant system and hindered from environmental discharge.

Publications (2021-2023)

David Livingstone, Beatrice M. Smyth, Gary Lyons, Aoife M. Foley, Simon T. Murray, Chris Johnston, Life cycle assessment of a short-rotation coppice willow riparian buffer strip for farm nutrient mitigation and renewable energy production, Renewable and Sustainable Energy Reviews, Volume 158, 2022, 112154

David Livingstone, Beatrice M. Smyth, Aoife M. Foley, Simon T. Murray, Gary Lyons, Chris Johnston, Willow coppice in intensive agricultural applications to reduce strain on the food-energy-water nexus, Biomass and Bioenergy, Volume 144, 2021, 105903

David Livingstone, Beatrice M. Smyth, Erin Sherry, Simon T. Murray, Aoife M. Foley, Gary A. Lyons, Christopher R. Johnston, Production pathways for profitability and valuing ecosystem services for willow coppice in intensive agricultural applications, Sustainable Production and Consumption, Volume 36, 2023, Pages 281-291,

9. References

[i] https://assets.publishing.service.gov.uk/ government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf
[ii] https://www.theccc.org.uk/publication/sixth-carbon-budget/
[iii] https://www.iggesund.com/sustainability/raw-material/fossil-free-energy/
[iv] https://electricityproduction.uk/plant/biomass/
[v] https://www.afbini.gov.uk/sites/afbini.gov.uk/files/publications/Short%20rotation%20coppice%20willow%20best%20practice%20guidlines.pdf
[vi] https://www.sciencedirect.com/science /article/pii/S0961953420304372?via%3Dihub
[vii] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/16.17.079%20Sustainable%20Land%20Management%20Strategy%20final%20amended.PDF
[viii] https://www.catchmentcare.eu/
[ix] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/16.17.079%20Sustainable%20Land%20Management%20Strategy%20final%20amended.PDF
[x] David Livingstone, Beatrice M. Smyth, Aoife M. Foley, Simon T. Murray, Gary Lyons, Chris Johnston. Life cycle assessment of a short-rotation coppice willow riparian buffer strip for farm nutrient mitigation and renewable energy production. Renewable and Sustainable Energy Reviews. Volume 158, April 2022, 112154
[xi]David Livingstone, Beatrice M. Smyth, Aoife M. Foley, Simon T. Murray, Gary Lyons, Chris Johnston, Willow coppice in intensive agricultural applications to reduce strain on the food-energy-water nexus. Biomass and Bioenergy 144 (2021) 105903
[xii] Effect of two vs. three year harvest intervals on yields of Short Rotation Coppice (SRC) willow. Christopher R. Johnston, Linda R. Walsh, Alistair R. McCracken. Biomass and Bioenergy Volume 156, January 2022, 106303
[xiii] Teagasc National Farm Survey 2017 Sustainability Report (2016, 2019). J. Lynch, T. Hennessy, C. Buckley, E.D. Athenry, C. Galway
[xiv] SRC willow as a bioremediation medium for a dairy farm effluent with high pollution potential. Edward G.A.Forbes Christopher R.Johnston John E.Archer Alistair R.McCracken. Biomass and Bioenergy Volume 105, October 2017, Pages 174-189