PERENNIAL BIOMASS CROPS

PBC4GGR

GREENHOUSE GAS REMOVAL

Rethinking perennial biomass crops implementation in farmed landscapes: designing opportunities for integration into the farming system

Deliverable 1: Report on potential PBC integration strategies

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1. Introduction

1.1 Background

The UK's Climate Change Committee's (CCC) Balanced Net Zero Pathway (for the 7th Carbon budget) envisages domestic energy crops contributing 7% of emissions reduction in 2040. In this pathway land allocated to biomass energy crop planting (Miscanthus, short rotation coppice, and short rotation forestry) reaches 0.7 million hectares by 2050 (annual planting rates rise from 0 to 38, 000 ha), which equates to almost 3% of UK land area. This has implications for land availability, the supply chain model for the feedstock to UK energy plants, for the scale and form of PBC production, and for the farmers and land managers' businesses. A changing context suggests that we need a reorientation in the way we think about PBC implementation.

These ambitions sit alongside competing land use priorities, including food production, biodiversity, reforestation, housing, and infrastructure, as reflected in the Land Use Framework consultation which calls for multifunctional land use (Defra, 2026). Evidence suggests that relying solely on marginal land will not meet planting targets, raising questions about how PBC can be integrated into more productive landscapes while delivering environmental co-benefits (Delafield *et al.*, 2024; Hodgson *et al.*, 2024).

Current policy and industry models largely assume large-scale, centralised supply chains. However, research indicates that more decentralised approaches may better deliver energy, negative emissions, and ecosystem service benefits (Donnison *et al.*, 2020). Importantly, decisions about whether and where to plant PBC rest with farmers and land managers, whose choices are shaped by economic advantage, market demand, and confidence in the stability of supply chains (Clifton-Brown *et al.*, 2023), as well as social and cultural factors (Ingram, Mills and Mackley-Ward, 2025; Warren *et al.*, 2016).

There is growing recognition that PBC could complement, rather than compete with, other land uses through multifunctional land strategies (Hodgson et al., 2024). Integrating PBC into farming systems, in ways that are profitable, resilient, and locally appropriate will require new business models, including private and public ecosystem service payments. Combining these with PBC feedstock payments allows diversification of revenue streams in a challenging post-transit transition environment, at an individual farm business or landscape scale.

Emerging evidence highlights the ecosystem service potential of PBC (Livingstone *et al.*, 2023; McCalmont *et al.*, 2017), but less attention has been paid to how farmers can practically integrate these benefits into viable farm businesses (Winkler *et al.*, 2020). In addition, findings from the Perennial Biomass Crops for Greenhouse Gas Removal

(PBC4GGR) study[1] with farmers and industry stakeholders underlined interest in smaller-scale planting, decentralised energy systems, stacked payments for ecosystem services, and the role of PBC in farm resilience (Ingram et al., 2025). Together, these insights point to the need for new, socio-economically grounded strategies for PBC implementation at both farm and landscape scales.

This is in the context of farmers looking for diversified revenue streams in a challenging and uncertain period of post-Brexit transition and market volatility.

1.2 About this project

Given the context above, this project aimed to rethink how PBC - specifically Miscanthus and Short Rotation Coppice (SRC) willow - can be more effectively integrated into existing farming systems.

Objectives:

1. **Identify opportunities for integrating PBC into farming systems at farm and landscape level**
2. Scope out the public and private sector mechanisms to support farmers and land managers in integrating PBC into their farming systems at farm and landscape level
3. **Co-design strategies and prototypes for PBC integration**

A key focus of this project was on identifying strategies that were profitable, resilient and practicable both at a farm and landscape scale. This included identifying past and current support mechanisms and revenue streams as well as exploring experiences of PBC growers. This project synthesises previous data collected as part of the PBC4GGR project Phase 2[2], with new evidence collected as part of the Flexibility Fund project, as outlined below. The analysis largely relates to the English context.

[1] PBC4GGH Phase 1 focused on existing growers and industry stakeholders across England and involved 9-10 interviews and one workshop per crop. The workshop stakeholders undertook participatory mapping of barriers and enablers to PBC upscaling identifying and unpacking these at industry, policy and farm level.

[2] PBC4GGR Phase 2 aimed to capture wider non-grower (farmer) and stakeholder views in four regions in England and Wales: North-East, mid-Wales, Yorks and Humber and Midlands selected to represent different biophysical regions, farming systems and market opportunities, with 16-18 interviews in each region. This was followed by a participatory modelling workshop in each region. Stakeholders included representatives of the farming and agricultural community, biomass crops industry, renewables and carbon removal sector, forestry commission, conservation and catchment management agencies.

1.3 Report aims and outline

This report will address Objectives one and three in that it presents potential strategies for integrating PBC into farming systems at farm and landscape level; these have been identified and 'co-designed' with participants.

Part one of this report aims to understand what PBC integration strategies have been deployed to date. It presents findings from the re-analysis of the Phase 2 PBC4GGR data and uses this to develop a series of **PBC grower archetypes and an opportunity scenario**. It will then present analysis of a series of in-depth stakeholder interviews focusing on participants' feedback on these archetypes and an opportunity scenario called 'the synergistic farmer'.

Part two aims to explore **potential PBC integration strategies** farmers and land managers might apply now and in the future. It will present the following strategies as identified within the interviews:

- On-farm business resilience, including circular approaches
- On-farm ecological resilience in terms of land management
- Existing and new products
- Ecosystem services

2. Methods

A qualitative approach was employed for this study. Data was captured from i) analysis of previous interview transcripts and workshop reports from Phase 2 of the PBC4GGR project; and ii) additional in-depth interviews.

2.1 Analysis of data collected in PBC4GGR Phase 2

This comprised extensive qualitative interview and workshop data as outlined above. The purpose of the analysis was to identify past and current on-farm PBC integration drivers and strategies. In particular we draw on the data from the regional workshops where participants co-designed hypothetical farms identifying opportunities based on scientific evidence of potential PBC co-benefits. These included diversifying farm strategies and incomes through, for example, payment for carbon sequestration, flood tolerance and biodiversity. The analysis informed the design of this study and particularly the in-depth interview schedule and prompts; namely the four archetypes and opportunity scenario.

2.2 In-depth interviews

In total 22 semi-structured **in-depth interviews** took place with 23 participants, with one landowner inviting their farm manager to join them. The purpose of this exercise was for participants to validate and comment on the four archetypes and opportunity

scenario, and to further identify and understand what strategies farmers and land managers might apply now and in the future.

Interview materials

Please see Appendix A for an example of the interview script. The diagrams referenced in the script are visual prompts (see section 3.2), as they represent the output from thematic analysis of the data collected in PBC4GGR Phase 2.

Sampling strategy and interview participants

Table 1: interview participants

Participant ID	Participant role
P1	Miscanthus supply chain
P2	Natural capital market consultant
P3	SRC willow supply chain
P4	Researcher and farmer
P5	PBC grower
P6	PBC grower
P7	PBC grower and farmer
P8	Agronomist
P9	PBC grower and researcher
P10	Agricultural adviser
P11	PBC grower
P12	PBC grower and farm manager
P13	Bioenergy plant operator
P14	SRC willow supply chain
P15	Miscanthus supply chain
P16	Catchment adviser
P17	Bioenergy researcher (carbon specialist)
P18	SRC willow supply chain
P19	PBC grower and farmer
P20	PBC grower and landowner
P21	Agricultural adviser
P22	Farm business consultant and PBC grower
P23	Natural capital adviser

A stakeholder analysis was conducted identifying relevant participants, including PBC existing growers, farmers, land managers, landowners, farm advisers, agronomists and land agents, biomass industry stakeholders and researchers. In addition, those with experience working in areas relevant to the co-benefits that PBC produce, such as natural capital markets, biodiversity and landscape scale and catchment approaches, were also identified. Participants were purposively sampled to represent these groups. A small number of the group had also participated in previous PBC4GGR research. In

some instances, sampling snowballed as participants suggested other potential participants. Potential participants were approached via telephone and / or email and asked to contribute or to suggest other potential participants. The participants are listed in Table 1.

2.3 Analysis

i) **Thematic analysis of Phase 2 data** resulted in the creation of the four archetypes. These represent past strategies to integrate PBC into existing farming systems. In addition, a fifth future opportunity scenario was devised, entitled the 'synergistic farmer'. The development process is outlined below:

- Phase 2 data was reviewed and analysed via NVIVO culminating in a series of four code clusters sitting under each of the PBC co-benefits (see Appendix B)
- Code clusters were further summarised and placed alongside potential PBC farmer archetypes (see Appendix C)
- This analysis informed the development of a number of integration **archetypes** and an **opportunity scenario, the 'synergistic farmer'** to use as visual prompts in the interviews.

ii) Deductive and inductive **thematic analysis of the in-depth interviews** interpreted findings for past, current and future PBC strategies. The interviews were transcribed and uploaded onto data analysis software tool, NVIVO. The data was then coded in NVIVO using semantic coding to characterise the archetypes (e.g., "stepping back") and latent coding (e.g., "endgame", with participants highlighting that growers were now pulling out PBC). These codes were then reviewed iteratively through discussions in the research team resulting in a code cluster map (Figure 1). Code clusters are both deductive - highlighted in square boxes - such as 'feedback on archetypes', and inductive – highlighted in cloud shaped boxes - such as 'value'.

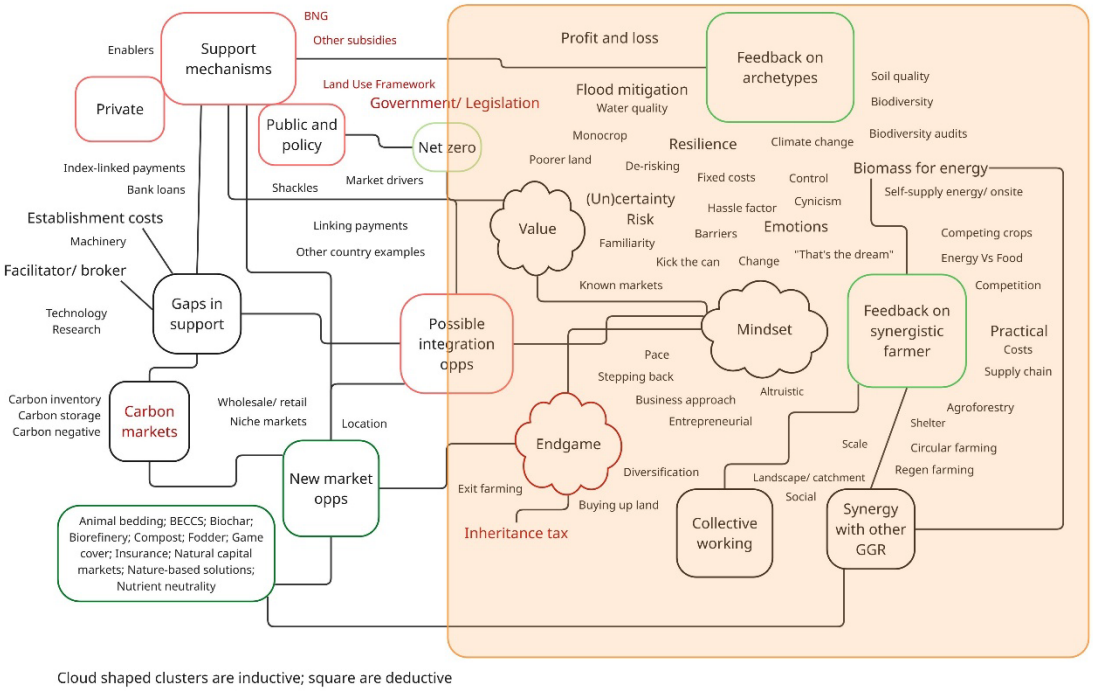

Figure 1: Mapped code clusters from interview data with a focus on archetype feedback

3. Findings – Part I

3.1 Phase 2 data analysis

Deductive thematic analysis of Phase 2 data resulted in the development of four interconnected archetypes and one opportunity scenario: These are summarised below.

Most Archetypes A to C represent growers planting between 2001-2009 with access to long-term contracts for feedstock and to planting support through the Energy Crop Scheme. They were attracted by low maintenance, few inputs, low labour demands, and reliable revenue from long-term contracts for feedstock.

3.1.1 Archetype A: Stepping Back (low maintenance farming)

The size and location observed for this type of grower was typically 5-10 hectares of both Miscanthus and SRC willow on least productive land not integral to other parts of the farming system. For some farmers, the decision to step back from more intensive farming enterprises was shaped by broader personal and business considerations. Health and wellbeing, retirement planning, family circumstances, or off-farm employment often play a central role in these decisions. Although payments are linked to yield, one farmer observed that yield was not always the key determinant: *"It*

depends on what you have to do to achieve that yield… we're willing to forgo yields if it also means less inputs and less effort", highlighting a more hands off approach and a willingness to accept lower biomass yields where it replaced the higher workload associated with livestock.

Advisers characterised these PBC growers in their area as having another income*: "Every farmer that we've got in the area has got another income, another job"*. Within this context, PBC are seen as a practical option to stabilise farm income while reducing time and resources otherwise allocated to day-to-day management.

3.1.2 Archetype B: Optimiser

This type of grower typically planted PBC in 20-30 hectare blocks of Miscanthus on unproductive land (in arable, mixed and livestock systems) and SRC willow in blocks of 20-300 hectares (livestock and arable systems). The main appeal is the reliable revenue from long-term contracts, but with a focus on optimising returns at minimum risk at scale. Larger arable farmers are taking out less productive parts of their land for Miscanthus. One grower (an estate manager) explained that as part of the large estate's strategy, the agriculture has to be low risk and Miscanthus fits that model well; *"We're not in the mindset that 'we've got to plough every acre and we're just here to grow crops and nothing else'".* Instead, the focus is to bring stability to the income. Traditional arable and livestock farmers describe transitioning to PBC because of the uncertainty of grain markets and the livestock sector respectively. One farmer noted; *"in some ways PBC [is] more stable, you can leave them in the ground- income will come at some point"*. In some cases, this was part of a diversified system, for example, one grower described spreading the risk on their farm with income from agri-environmental schemes, renting out to livestock, and solar panels on the shed roof.

3.1.3 Archetype C: Resilient (de-risking)

The size and location of PBC planting observed for this type of grower was typically 5-10 hectares on land most at risk of flooding and riverine areas not integral to other farming operations. Adapting to increasingly regular flooding in some areas has shifted priorities for some farmers away from arable cropping to flood tolerant PBC which can offer a reliable crop and income. As one adviser noted, *"Farmers spend a lot of money on putting things on the land, which, if there's then either flooding or heavy rain, they lose. And then literally the money is just being washed away… anything which can help keep the fertilizers and nutrients, the quality topsoil… those are strong arguments for doing it"*. Farmers also noted that crops established on frequently flooded riverbanks may not be harvestable, suggesting that in such areas PBC may serve primarily for flood mitigation rather than commercial cropping.

3.1.4 Archetype D: Green Values

The size and location observed for this type of grower was 5-10 hectares on non-productive land and not integral to a wider farming system. Growers typically managed smallholdings and PBC planting was often self-funded or part of a sustainable initiative such as One Planet smallholdings in Wales. Some farmers expressed strong 'green' values and grew PBC to enhance biodiversity, improve soil health, and contribute to carbon sequestration. Motivated by climate change and the energy transition, this group often placed nature recovery and environmental stewardship at the centre of decision-making. PBC were viewed as less of a commercial crop and more as a means for delivering local energy and environmental benefits: "*And I think this biodiversity argument, it's certainly why I know our next-door neighbours wanted to have it, really matters much more than, 'oh, there's going to be a carbon benefit in this'. And even almost a little bit more than the financial*". On smaller farms, particularly those with biomass boilers or part of larger estates, PBC offered an opportunity to generate energy on-farm while also contributing to wider environmental goals.

3.1.5 Opportunity scenario: Synergistic Farmer

The 'synergistic farmer' represents a future opportunity for farmers to integrate PBC on the farm and combine or stack different revenues from PBC contracts and natural capital payments. The suggestions arose from the participatory workshops in Phase 2 which discussed how value could be derived from the PBC co-benefits. Workshop stakeholders identified opportunities for PBC to generate payments for biodiversity, flood mitigation, and carbon sequestration, while contributing to farm-level net-zero goals, which could be stacked for one piece of land. Participants, however, also noted that diversification and combining income streams will be challenging and involve investment and transaction costs (time, effort) to support strategic planning. They need to maintain some versatility due to the uncertain context: *"We've got to think so many moves ahead. It's very difficult to know. So, one of the strategies will be keep flexibility. Give yourself a number of avenues to go down".* Such decisions will require some risk taking, strong advisory support and, if they are tenants, suitable tenancy arrangements.

3.2 Phase 2 output as interview prompts

The following visual interview prompts, Figure 2 and Figure 3, were devised from the analysis outlined above and used to accompany the interview schedule for the second stage of data collection. The figures present each of the archetypes, their primary PBC benefit, and the key goals and drivers associated with that strategy.

Figure 2: Interview prompt one – The Archetypes

Figure 3: Interview prompt two - The Opportunity Scenario: Synergistic Farmer

3.3 In-depth interview analysis

This section presents findings from deductive thematic analysis of the **in-depth interviews**. Key observations to note are:

- Participants engaged and related to each of the PBC grower archetypes
- Participants cited many examples of each archetype in practice
- Many participants suggested amendments to the archetypes; giving some priority over others and also suggesting how some PBC growers were made up of a combination of archetype groups
- The majority of participants were not aware of new farmers growing PBC
- Some participants spoke of growers pulling out PBC
- Consensus that the opportunity scenario is a positive development, but a few were unsure as to how realistic it was in practice

3.3.1 General feedback on archetypes

The majority of participants related to the four archetypes as good representations of PBC growers and went so far as to recognise themselves and colleagues within one or more of the archetypes. Some felt that the archetypes are now outdated as the support that enabled them (Energy Crop Scheme) is no longer available, others felt that it would not take a lot to encourage farmers to plant PBC.

> *"Yeah, I do. Yeah, yeah. Yeah, I think I'm between C&D"* (P12, PBC grower and farm manager)

> *"I would say identify with those... in the over the last few years of talking to people there. Yeah, pretty, pretty, pretty accurate"* (P4, researcher and farmer)

Supply chain participants saw these categorises as audiences they targeted, but not necessarily successfully:

> *"Yes, these [A&B] are both archetypes we actually target, and we use exactly these arguments.... so this one optimiser very difficult to find, even more difficult to sell if it's not him coming to us. If he comes to us, there's no sell. He will buy, because he understands"* (P1, Miscanthus supply chain)

Participants gave variable responses when asked if they were aware of any new PBC growers. The majority were not aware of new farmers growing PBC; moreover, some gave examples of situations where growers were pulling out crops. For SRC willow, one participant spoke of a growing trend of removing the crop (P14).

Some were more positive, with one participant describing recent conversations they were having with potential growers and how they farmers were realising the multiple benefits PBC have.

> *"... these are recent conversations and they are happening, you know, right now and tomorrow, for instance, I'm talking to somebody about a particular type of high biomass crop and, you know, people are realising that perennial crops do offer quite a few solutions"* (P2, natural capital market consultant)

3.3.2 Observations specific to each archetype

That participants related well to the archetypes is further demonstrated in the analysis below and examples given of archetypal behaviour.

3.3.2.1 Archetype A: Stepping back

This was a well observed group, the majority of which were made up of two distinct groups; farmers at or close to retirement, also referred to by participants as *"armchair"* growers (P1, P9); and those who have a job off-farm, such the those who may have inherited the farm, but work elsewhere because they never intended to farm or can't make a living from farming alone.

> *"I've met some of these people. They're like 80-85-90. Even. Yeah, they don't want to let go. They know they can't continue. Sometimes they have sold everything, and they may be left with their first tractor in the in the barn. They would not sell it. They know they will never use it. But they're so connected to it. They don't want to let go. So they find they are searching for something which keeps their farm alive, which lets them continue to say I'm a farmer and I've always been a farmer and I will be able to give to my kids who might not farm or who might not afford to farm, something which pays for itself"* (P1, Miscanthus supply chain)

> *"So those that there are other cases where the farm has already been handed over, it's owned by the children. They come once a year, twice a year, Christmas, whatever. And the father still runs it"* (P1, Miscanthus supply chain)

Participants observed an element of having to 'step back' from conventional cropping and grow PBC on-farm because existing markets are becoming less and less "financially secure" (P16, catchment adviser), citing it as a way of keeping land profitable with minimum input, allowing farmers to focus on other markets. This is an observed crossover with archetype C.

> *"I'm not sure we would still have our family farm if we'd not- if we had gone into Miscanthus with everything that happened to our family with a- personal circumstances and what have you in the economic climate that we've been through"* (P22, farm business consultant and PBC grower)

Those who consider themselves in - or give examples of those within this archetype A group - spoke positively about this type of grower in terms of freeing up time (P6), suiting their lifestyle (P4), and enabling them to keep farming (P15).

3.3.2.2 Archetype B: Optimiser

This archetype was recognised for different reasons. Some saw themselves in respect of optimising land use and achieving an income*; "it gives us a return per acre of £300 plus an acre per year clear after all costs, and so it's a lot better than any sort of land rental"* (P6, PBC grower). This grower was also referred to as more of an *"accountant"*, or *"bookkeeping farmer"* (P1), not affected by an attachment to the farm that drive archetype A.

Others also saw synergies with archetype C, as participants felt that optimisers used less productive parts of their farm to gain an income instead of struggling with another crop (P11, PBC grower), or *"fight fields that are tricky"* (P15, Miscanthus supply chain). Another example saw growers optimising land use to produce a crop to use on-farm to *"reduce the links in the chain"* (P3, SRC willow supply chain).

There were also variable responses in relation to how common archetype B is. One felt this archetype was *"rare"* (P1, Miscanthus supply chain), while another said they interact with them often.

> *"I see those all the time. You know, there are, there are farmers out there who believe that the only way to you know to profitability is maximise yield. I don't agree with that, but there's definitely lots of them out there. And they are finding life pretty hard at the moment because they're generally going for out and out production, not diversifying, not trying to build resilience and therefore finding it quite hard"* (P2, natural capital market consultant).

3.3.2.3 Archetype C: De-risking

Some participants questioned what was meant by resilience and de-risking, for example, how PBC were helping farmers to build resilience throughout their business and protect from market fluctuation.

> "*Archetype C is really where we're spending most of our time. You know, we're looking at helping people build not just about flood resilience, but you know about building resilience throughout their farming business*" (P2)

One grower planted Miscanthus two decades ago to de-risk his business and is now - finding that soil quality in those fields has improved – and has taken out some of the Miscanthus and planted cereal crops back in. Another example of combining archetypes, in this case C&D is described here:

> *"So, he took what was a less productive bit of the farm, put it into Miscanthus to de-risk his business, manage the flood, give him some guaranteed revenue without any work or too much effort. But now, 20 years on, he's in a position to say, actually I can take that out of that biomass now, put it back into normal cereal cropping and almost reap some cash rewards from that by growing a*

*cereal crop with very low inputs because [he'll] be working off all of the soil benefits built up over the last 20 years and I can grow a low cost but high yielding winter wheat crop off that field in two years' time" (*P13, bioenergy plant operator)

Another participant suggests that for some farmers it is the only way they can get an income of land that frequently floods.

> *"Every farm's a business and it's not really going to bring any income from flood. I mean, there are farmers who have got pieces of land that do flood so that it is- it's either getting income, potentially income from [PBC] because they can't get anything else on that piece of land and that's the main reason"* (P14, SRC willow supply chain)

There are competing priorities (and goals) that PBC can potentially serve while de-risking; one participant noted farmers have a duty to both "become resilient to weather and income" (P16, catchment adviser). P2 (natural capital market consultant) expands on this with a wider understanding of what resilience means.

> *"I think when I talk about resilience, it's about a lot more than just protecting against flooding or climate, other climate related issues. It's about protecting oneself from market fluctuations, from the whims of supermarkets and consumers, it's about, you know, ensuring that you have a business that, you know, makes money year after year after year, but also is able to do so whilst still you know, building resilience against climatic issues"* (P2)

The archetype C group are seen as innovative, "protecting waterways" (P17, bioenergy researcher), potentially already having the characteristics needed for a more synergistic approach to integrating PBC.

> *"The yield and flood mitigation, these are usually kind of more innovative farmers that can see how the lands kind of fits in with energy crops like sheltering from wind, I've seen that before protecting waterways as well. I've seen that and say if they've got like a problem with the waterway, that could really suit them quite well. I've seen that before"* (P17)

Note: These are some examples of farmers growing PBC to de-risk their land and protect it against flooding. There are currently no grants or incentives to do this. Participants noted that for the majority of farmers they spoke to, using PBC in this way would require an incentive such as a those offered under SFI or via payments from a water company or insurance company.

3.3.2.4 Archetype D: Green values

> *"No farmer plants Miscanthus because it's green. Why? Because they're not getting paid for it. If you do the right thing, but it doesn't help your farm financially, your first target as a farmer is to survive, to hand over the farm to your kids. So, if*

it doesn't pay off, you're not going to do it. You might know it should be done, and you might understand why it's good for your farm in the long term and for the humanity and the UK and the net zero goal and all this but they will not do this so this is not a, this is a, let's say green side benefits are just that, side benefits" (P1)

The above quote is an extreme example of a general shared opinion amongst interviewees that green values are not a key driver for planting PBC, but that achieving 'green outcomes' is a co-benefit.

"I think at the minute archetype D is probably a nice add-on. You know, it'll be well, I want to optimise my yield and if it's green while I'm at it, great, but I think we've got very few of their number one goal is archetype D. I can think of one person out of all of the people that I'm dealing with that's probably a D" (P15, Miscanthus supply chain)

"I think the last one personally would, I would say, is more led by corporate and policy that- and then that potentially, not forces but, but probably changes the mindset of the farmer to go down that route. I do know I have got a couple of clients who have always been very environmentally focused, but again I would say that is probably been more from what they've been exposed to in their other industries and their other professions, which I think it would be if you really looked into it and it would be from policy and NGOs and lobbying and those sorts of things that has then led them to go down that line. I think if you were to really look at it, you know the key to all of this is profitability" (P22, farm business consultant and PBC grower)

Within this response, participants characterised archetype D growers as having smaller scale, and / or being 'lifestyle' farmers, such as those coming into farming later in life with significant investment and wanting to make a difference. This resonates with the data from Phase 2, on which the archetypes were based.

"We've all met some more, sort of like more altruistic sort of approaches to like introducing crops because they just want to have a more healthy sort of system and promote biodiversity. They're usually really small scale, though. I think these guys [have] small land, all very wealthy, you know, because they can afford to do that" (P17, bioenergy researcher)

Participants noted a difference between PBC, with SRC willow having more biodiverse features, such as flowering for early pollinators, being native and having more species variety (compared to Miscanthus), as well as offering shelter and nutritional browsing.

"The willow when it was in, was one of them food sources for like for the months of the year that was flowering and that it was, yeah, that was a great food source

for insects and birds and a haven for the deer and that" (p12, PBC grower and farm manager)

3.3.2.5 What's missing?

When questioned on the archetype's characterisations, some participants suggested amendments and additions. A couple of the participants warned around the language of 'stepping back' attributed to archetype A. They felt that the characterisation incorrectly builds on the perception that PBC need very little cultivation input and does not reflect their experience that PBC requires good management – albeit reduced - to improve its establishment to ensure a good yield.

> *"I think from my point of view, I think that one day a year, one day every three years with willow is the truth but I really think I'm with my kind of agronomy hat on, it can be a slightly dangerous message to new adopters, though, because that happens, but only if you get it right in the beginning. So you need to get your preparation and maybe the kind of three to six months post planting absolutely spot on that if you get that right, it is an armchair crop and you can step back, but if you get it wrong, it's just a complete disaster and I think that's both for willow and Miscanthus"* (P9, PBC grower and researcher)

> *"Terravesta [main Miscanthus supplier] were adamant it has no nutritional requirements. But I said when you're on Warwickshire clay that is index 0 or index 1 phosphate - and you're talking about a root that needs to get some good roots down, and to make a crop that grows above ground. So I said it. That makes to my mind as a farmer, I said it was a no brainer to keep using the [planned sewage] sludge that first year anyway"* (P5, PBC grower)

Some participants noted that the PBC farmers they knew were not represented by any of the archetype examples. These included farmers diversifying into new markets, such as animal bedding either to sell on or to use on-farm as bedding for their own livestock. This is reflected in one grower who anticipated using SRC willow on-farm for their cattle to browse or crop and put down as feed, again keeping the crop on-farm.

> *"For grazing, for grazing the sheep... there's a grazing material. Yeah, I have a real interest in that, Yeah, grazing trees, especially the willow... Even, you know, like putting electric fence around and letting cattle graze the leaves as well"* (P12, PBC grower and farm manager)

A few participants suggested that PBC growers are using the crop as feedstock for their own biomass boiler.

> *"I think there's maybe an assumption here that it's going into a commodity market for power plant or an end user, but maybe there could be a cohort that's self-supply, so they've got a biomass end use and they're growing for themselves.*

I don't know. I'm just kind of shooting from the hip here, but maybe they're missing and I think they're an important cohort because actually they're just quietly getting on with it and if they're displacing, say, bought in heating oil, it's probably quite economic for them. They've taken control of their businesses, energy security and they're quietly de-risking their business and they might not be making a song and dance about it, but I think yeah, thinking where, who the end user is and splitting between yep, selling, selling, or self-use might be worth looking at" (P9, PBC grower and researcher)

"I know very few other farmers who are growing Miscanthus. Thinking about it, no, the other two farmers, I do know who grew Miscanthus and or grow Miscanthus and doing it on any sort of scale and persisted with it, don't fall neatly into either of these. One is growing it for processing, for animal bedding and the other is growing it purely as a fuel for his biomass boiler to heat his poultry side" (P7, PBC grower and farmer)

With each of these additions, participants are anticipating and then describing the second prompt – the synergistic farmer, which is explored later in this report. Finally, one participant spoke of a type of PBC grower who is not a farmer but buys farmland and plants PBC as a low-input crop alternative on which to gain an income (P1). Another spoke about growers further down the supply chain who are not farmers but are planting PBC because they are unable to source enough biomass feedstock.

"so another cohort can actually just be end users that are cultivating the crop themselves because they or managing the crops themselves because they can't get farmer uptake" (P9, PBC grower and researcher)

3.3.2.6 Combining archetype types

A large number of the participants noted how one PBC grower might demonstrate different archetypes' characteristics.

"Yeah, like you say and a mix of them as well. You know, it's although they are in four boxes, there's probably elements of a farmer in each one really" (P4, researcher and farmer)

"I think all of them could be drawn into one individual farmer for many multifaceted reasons" (P5, PBC grower)

"Obviously, it's more like a Venn diagram where somebody might be 60%, a 40% Do you know what I mean? So, there's a lot of crossover" (P15, Miscanthus supply chain)

A few recognised themselves as fitting into more than one archetype.

> *"Well to a certain extent, I mean, I fit into certainly almost three of those. I'm probably not the, I'm not B, I'm not the optimiser as such. But I mean I- I'm now stepping back and semi-retired and you could argue that my sole agricultural activity in 10 acres of Miscanthus, but yes, it's very low maintain- low management time, terribly easy, about two- two or three telephone calls a year and that's literally it"* (P6, PBC grower)

Some didn't want to pigeonhole farmers and saw the archetypes as relating to all farmers, not just PBC growers, highlighting comparisons to the 'right crop, right place' approach to agriculture generally.

> *"I think they're all types of farm and all types of individual. But as always there's a balance between those types of farmers and then the actual practicality of the nature of- is this the right thing to be growing here?"* (P8, agronomist)

One participant felt strongly that archetypes C and D were a subgroup of archetypes A and B, with yield and profitability being the key driver: 'stepping back' or armchair farmers deriving an income with minimum input or 'optimisers' maximising productivity on unproductive fields including those impacted by flooding.

> *"I'm not saying that the arguments you're having here C&D are wrong. They're right, they all exist. But I think that by itself they do not form a category because there is no force strong enough to convince a farmer to do the right thing, either C or D because it doesn't pay"* (P1)

There was very little negativity directed at the archetypes over participants who wanted to recast them. Only one participant questioned the practicalities of the archetypes, and that they should not exist on their own but should be driven by what is viable and right.

3.3.3 Opportunity scenario

Deductive thematic analysis was also conducted to address specific questions relating the second prompt, the opportunity scenario, which was labelled as 'the synergistic farmer'. A reminder of those questions is below:

5. *Have you seen others do this? Is it realistic?*
6. *What conditions / future mechanisms would need to be in place for this shift? / for you to make this shift?*

   Prompts: such as new policy instruments (like SFI), natural capital markets

7. *Where are there gaps in support?*
8. *What future opportunities have we missed? New markets? Community energy?*

   Prompts: New policy instruments; ecosystem services; other natural capital revenue; other GGR options such as biochar

9. *Have you seen farmers working together planting PBC or other land managers (estates, national parks etc) planting PBC at a landscape scale*

The majority of participants greeted this opportunity scenario encouragingly, and as highlighted above had even pre-empted where they had seen PBC growers do this.

In summary, there were many positive comments when participants were presented with this model (P11/P15):

> *"I actually think that's quite a good idea, as in using that- the crops to generate multiple incomes"* (P11, PBC grower)

> *"I think the days of a farm doing one thing are pretty much gone. You're going to have to have various income streams"* (P15, miscanthus supply chain)

With some describing seeing this in practice and working with partners to achieve it as P1 (Miscanthus supply chain) goes onto to detail.

> *"We have a farmer who has invested in a machine to produce horse bedding… He doesn't have enough land, so he will need to buy the material in from others. So we have been partnering up with him and we are holding these farm walks whereby he invites his neighbours and we explain that if they plant Miscanthus he will be their market and if he for some reason in that single year or in that single month cannot take all of it, what they produce, we as a company selling to the power stations, will act as a backstop"* (P1)

One felt this was a model they were trying to encourage (P2), others saw its potential for generating multiple revenue streams via the multiple benefits of PBC, such as improved soil quality, reducing use of chemicals on-farm, and flood mitigation. Some referred to the synergistic farmer as *"the dream"* (P9) and acknowledged the need to dream big. However great the idea in theory, many participants felt it would be challenging to achieve in practice. Conditions were placed on the model in relation to farm location, end markets, investment needed including SFI support, operational and infrastructure considerations, and business acumen required.

> *"you've got to be profitable before you diversify whatever that diversification is… I think a lot of people think by diversifying, they will suddenly change a £20,000 loss into a £40,000 profit and I think actually key goal to me would be understanding the business, understanding the good things, the bad things before then going down the diversification, multiple income streams and all the rest of it"* (P22, farm business consultant and PBC grower)

Much of what was coded under the synergistic farmer model, specifically around conditions and support required to achieve this also fed into the development of possible PBC integration opportunities. These observations are outlined in part two of this report.

4. Findings – Part II

This section builds on the analysis above and presents **potential integration strategies** as identified from participant interviews under the following intersecting groups of strategies:

1. On-farm business resilience, including circular approaches
2. On-farm ecological resilience
3. Existing and new products
4. Ecosystem services

These are represented in the matrix below (see Figure 4) with one axis for business to ecological resilience, and one axis for new practices to new markets. Although described separately, there are opportunities for overlap. The majority of the strategies suggested came from participants' own or other known practical applications, prompted in part by the archetype discussion. Participants were also asked to think aspirationally, prompted in part by the opportunity scenario.

These are shown in the four quadrats in the matrix in Figure 2 where one axis represents business to ecological resilience, and one axis represents new products to new services.

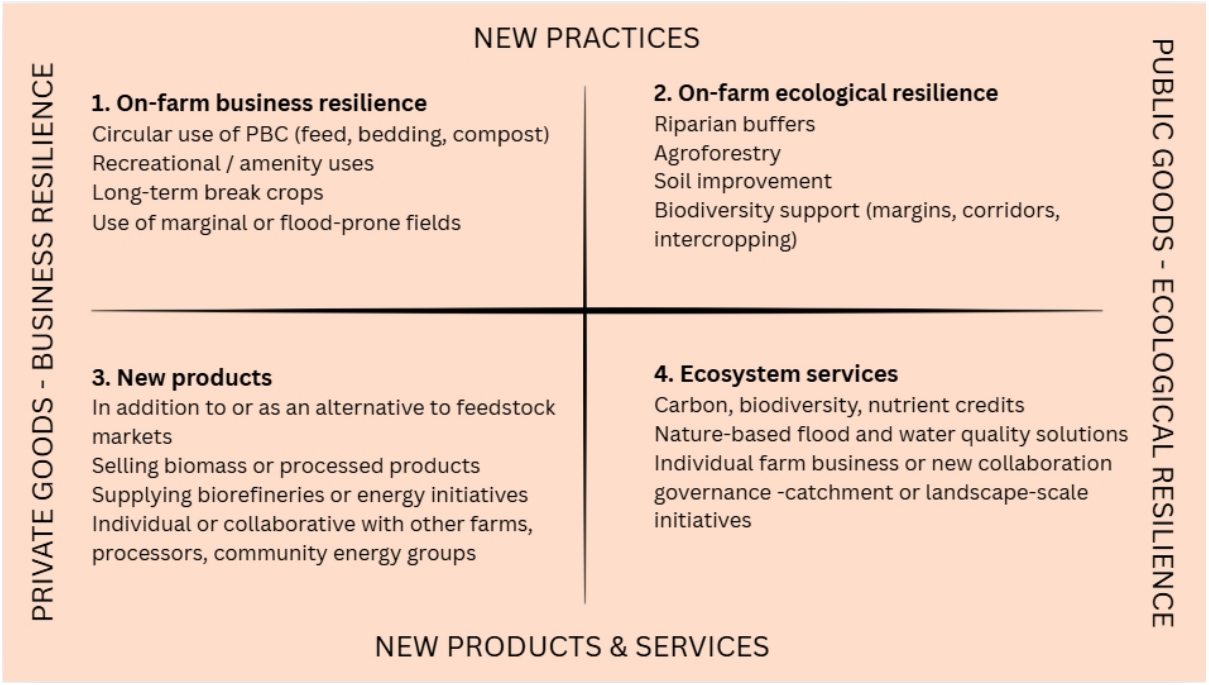

Figure 4: Matrix showing PBC potential integration strategies drawn from archetypes and participants' insights

4.1 On-farm business resilience, including circular approaches

The first of two farm-centred strategy groups is situated in quadrant one (Figure 4) and involves diversifying the planting and use of PBC on-farm to enhance farm business resilience. Based on their own practices, participants proposed a diversification approach which saw farmers (who may already grow and sell PBC as feedstock) using Miscanthus as livestock bedding, feed and compost (P1, P12, P18), on-farm and so reducing the need to buy in products while also supporting a more circular approach.

> *"I'm surprised more sheep farmers or beef farmers in mid Wales haven't grown it the way I'm growing it and cut it for bedding because it saves some hauling straw in from England"* (P4 researcher and farmer)

In addition, and in relation to suggesting SRC willow be planted as a grazing material, participants suggested considering agroforestry approaches, and planting strips or sections of SRC willow (P14, P21) within fields usually reserved for livestock. One participant (P15) spoke of a client who has constructed a Miscanthus maze at their farm alongside other visitor attractions such as a farm shop, therefore expanding income streams.

Linking back to discussions about the opportunity scenario and the synergistic farmer, participants warned about the risks of diversification; *"you've got to be profitable before you diversify whatever that diversification is"* (P22, farm business consultant and PBC grower). They noted that the farmer and landowner need to have a full appreciation of the farm business, opportunities and threats before seeking to diversify.

Participants also suggested integration strategies in collaboration with other businesses within and outside of agriculture. Some suggested working with neighbouring farms to combine PBC hectares to facilitate contracting machinery to realise economies of scale (P4). One participant described a collaboration he was aware of.

> "*There is one who has said, oh great, I have a truck which is standing idle half of the year. I could be your haulier; I'll bring the straw in from your neighbour. Great. And another one said well, I bought just a forage harvester for £900,000, I'm only using it four months. Can I be your contractor?*" (P1, Miscanthus supply chain)

4.2 On-farm ecological resilience

The strategy group in quadrant two also involves changes in on-farm practice but with an emphasis on building farm ecological resilience. This was popular amongst participants with many proposing potential strategies for integrating PBC within farms such as agroforestry and buffer strips. For example, one suggestion was planting riparian buffer strips to help mitigate and reduce impact of flooding and nutrient run off, whilst also improving soil quality; *"you wouldn't even necessarily have to harvest it, you could just leave it there, but it would help slow that stuff down and soak up some of the*

stuff" (P15). In addition to on-farm benefit, this would also help land managers comply with regulations such as Farming Rules for Water. Participants were aware of how other countries planted PBC to manage water quality.

Participants also suggested ways in which PBC can support and increase biodiversity (with a view to increasing biodiversity units), where this co-benefit could be evidenced. One spoke of their experience planting strips in a way that increased the edges of the crop available; encouraging birds to seek the strips as protection as opposed to planting as a dense monoculture.

> *"It was only around the edges of the [PBC] crop that we seem to get much bird life, and I guess you know the invertebrates would sort of follow that if there was a lot lots of bugs about then the birds would be more active in the crop, but within the main body of the crop there was very little biodiversity, which was a big disappointment. But I think it's a realistic assessment"* (P7, PBC grower and farmer)

In relation to links between ecological resilience and livestock health, a few of the participants spoke of personal experiences with, and emerging research into, SRC willow as a livestock feed that reduces methane production and so could have a direct impact on greenhouse gas emissions and ultimately the farm's GHG assessment (P3, P4, P14).

> "*So, either as a browse or for harvesting to kind of make a feed. So, I guess the fodder application specifically of willow is something that's emerging and yeah, that's of interest to me"* (P9, PBC grower and researcher)

Across both of these strategies, participants placed value on PBC as more than just an energy crop to be sold and felt it could be an integral option to help build ecological resilience across a farm. For example, as feedstock for an on-site biomass boiler reducing heating costs, and as a bedding neutralising acidity and improving the health of livestock (P4, P18).

> "*We're not just planting it to get the water quality better, it's this land use thing, it's creating that buffer, physically, it's a shelter thing, it's something you can use on a farm to heat the farm or bed your cows on you know it's that whole selling the integration of it really*" (P4, researcher and farmer)

4.3 Develop existing and new products

The first of the new products and services strategies sits in quadrant three and pulls together suggestions made by participants to develop existing and new products, adding value to the crop post-farm gate. Many participants had experience selling processed PBC locally, developing their own markets as a result of conversations with other and neighbouring farmers. One farmer who grows and processes PBC as

feedstock for their onsite biomass boiler already sells any surplus crop to a local contact who is producing horse bedding with Miscanthus; *"that would be the obvious route to sell more to him because he's always looking for more product"* (P7, PBC grower and farmer).

Some saw a collective farmer approach as an opportunity to serve local community energy needs as a feedstock producer for small biomass boilers or plants.

> *"There are, there is some crappy land, but you know, we could quite easily put a plant in the village, and everybody could bring a couple of hectares of willow and Miscanthus and then, you know, we've got energy for the village, you know, and the windmills going as well. You know that sort of community approach*" (P4, PBC grower researcher)

One supply chain participant described multiple end markets that already exist for them as well as models for expansion opportunities.

> *"we've got wholesale to the power stations, we've got retail, what we call retail to the end user biomass with RHI[3] on them. We've got animal bedding; it's very, very small at the moment, compost market, the biggest opportunity"* (P18, SRC willow supply chain)

As well as animal bedding and compost, participants noted that growers could produce any number of PBC products, including briquettes and biochar. Other future products discussed (by those who seek to develop the PBC sector) included biorefinery; *"we've been steam exploding Miscanthus and get cellulose and hemicellulose out of it, which could be used as a sugar replacement or a probiotic precursor"* (P4, researcher and farmer). Construction was another sector highlighted.

> *"I think where Miscanthus could be amazing is if- because we've got people in looking at it in the construction sector, you know looking for eco bricks and eco boards and that kind of stuff. If the grower were to not burn it in a power station and that was put into a brick or a board, and that board was put into a house for the next 100 years, that above ground biomass that's taking in the 27 tonnes of carbon, if that's then chucked into a board, chucked into a house, different scenario"* (P15, Miscanthus supply chain)

However, given the enthusiasm it was noted by a few participants that many of these larger markets required quantities of PBC at scale that has not yet been achieved.

> *"You need a market, but basically there are markets. It's just that these markets. Let's say require quantities which are not supplyable. So, it's a chicken and egg*

[3] The Domestic Renewable Heat Incentive (RHI) was a government scheme to help fund domestic biomass boilers

issue. When there's supply, there's sufficient demand, yes" (P1, miscanthus supply chain)

4.4 Develop ecosystem services

The second of the new products and services strategies in quadrant four is based on the PBC co-benefits. These included the kinds of environmental improvements that positively impact local catchments and the wider community 'for public good', generating carbon and nutrient credits for natural capital payments. This is relevant to individual farm businesses or new collaborations.

However, participants were cautious about these new markets which requires a greater level of scrutiny and understanding before being a viable option for them. Within the data, voluntary carbon markets were described as "embryonic", a "minefield" and the "wild west". Very few participants were positive about it as an integration strategy for farmers for now. However, those working in these markets saw this as growing sector with opportunities ahead.

> "*I couldn't look every farmer in the country in the eye today and say to them that if you make these changes and grow these crops, you will be able to derive a new income in the form of carbon offsets. What I do know is that the market is accelerating and so there are a growing number of organisations who are going to buy these things and there are a growing number of farmers that are receiving income as a result*" (P2, natural capital market consultant)

There were also a few participants who described more aspirational integration opportunities at a landscape scale, using Miscanthus and SRC willow to help manage water quality and mitigate flooding. They suggested that farmer clusters working at landscape scale would have more "clout" (P23, natural capital adviser) and proposed approaching catchment actors such as river trusts and water companies seeking nature-based solutions with multiple outcomes including improved community relations.

> *"Water companies have this kind of either compliance driven money or wanting to look a bit good and create good local marketing"* (P23)

> *"And then the by- product of [SRC willow] … it also slows or catches debris, which from a social point of view is a benefit"* (P14, SRC willow supply chain)

However, caveats were raised in respect to farmers ability to "*coordinate themselves*" (P21, agricultural adviser) to explore the kinds of options available to them; *"I mean, these are all great ideas, but it takes a little bit of organisation, doesn't it?"* (P21). Questions were also asked about catchment management actors' awareness of the flood mitigation benefits of PBC.

> *"So, in Somerset, for example, they're really hot on that and thinking about water quality. And I think these crops could be seen as helping to protect them and that that could lead to payments, but again I think the Miscanthus guys are pushing that down there and it's kind of closer to market, but yeah. And. And I suppose going on to opportunities with water, rivers trusts and water companies, there's potential there. But do they really know it's an option on the menu list?"* (P9, PBC grower and researcher)

Also, some participants felt that PBC were not biodiverse enough to be considered an appropriate option for Landscape Recovery projects; "*ultimately, what we want for the cluster and the landscape is an integrated system of nature and food production"* (P16, catchment adviser).

On the whole, however, participants shared innovative ideas that drew attention to the benefits of PBC beyond an energy crop, opportunities that could potentially increase its perceived value. A few suggested seeking relationships with the insurance sector to develop nature-based risk management solutions.

> *"I think there could be so many so much benefit there if we could get [an] insurance company, we could save them an absolute fortune rather than putting all this money into concrete walls, which then get over- the water goes over the top, we could slow water down. I mean, and as I say hold debris back"* (P14, SRC willow supply chain)

> *"Similarly, if insurance companies are not wanting to take insurance premiums from people because of the fact that they live in catchments where there's likely to be flooding, they're turning their nose up on potential money. If they could invest in solutions like flood mitigation. Then again, that could be something that could help them invest in something that could lead to them getting more money"* (P3, SRC willow supply chain)

5. Conclusion

This report presents potential strategies for integrating PBC into farming systems at farm and landscape level; these have been identified and 'co-designed' with participants. It combines findings from the PBC4GGR project with 23 new in-depth stakeholder interviews. Analysis was used to identify four PBC grower archetypes and an opportunity scenario which were validated and evaluated in stakeholder interviews:

- Archetype A: Stepping Back (low maintenance farming)
- Archetype B: Optimiser
- Archetype C: Resilient (de-risking)
- Archetype D: Green Values

- Opportunity scenario: Synergistic Farmer

Building on the interviews, the following potential PBC groups of integration strategies were identified and explored:

- On-farm business resilience, including circular approaches
- On-farm ecological resilience
- Develop existing and new products
- Develop ecosystem services

Participants expressed varying levels of optimism about these strategies. Whilst they recognised potential opportunities for diversifying income, they were also aware of the associated risks. Whilst new products and services are being developed and emerging evidence about PBC co-benefits is emerging, less attention has been paid to how farmers can practically integrate these strategies and sustain viable farm businesses.

This report provides the foundations for the next stage of analysis reported in Deliverable 2 which outlines support mechanisms that might enable farmers to implement these strategies.

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Appendices

Appendix A

Example interview script for PBC growers and advisors

Thank you again for your time. Have you been able to read the information sheet?

> *Explain the consent process and send them a link to the consent form.*

The aim of this research is to identify strategies and mechanisms for integrating perennial biomass crops onto farms to both optimise yield AND co-benefits, such as flood mitigation, carbon storage, biodiversity. The findings will be useful for policy makers, biomass industry and farming/land stakeholders.

This element of the study was prompted by discussions with farmers and stakeholders who are seeking creative ways of diversifying income. It draws on 80 interviews and 6 workshops across England and Wales, and specifically from 4 regions: mid Wales, the North East, Midlands, Yorks and Humber.

We would like to 'sense check' our analysis and would emphasise that we are looking forwards at the potential opportunities.

> Click record

We would like to 'sense check' our analysis and would emphasise that we are looking forwards at the potential opportunities.

First, I would like to introduce four archetypes that we observed within the data, please look at the diagram (these are indicative, not set in stone).

Then - These tended to reflect growers who have planted PBC using the energy crop scheme (ECS) in the early 2000s, reflecting a different set of motivations and conditions to now.

> *Read through each of the archetypes – ideally one at a time – and ask the following questions.*

1. Do you recognise these (in others, yourself)?
2. Would you agree it's a good characterisation? Explain, if not why? How common is this sort of archetype?
3. Who is missing?
4. Are these sorts of farmers still **starting** to grow PBC?

Now – The Energy Crop Scheme is no longer available and planting PBC requires high investment. However, farmers are increasingly understanding that transition to net zero is important, they are losing their basic payment scheme and seeking a more resilient way of farming (given weather, policy, market unpredictability).

> *Present the opportunity scenario 'the synergistic farmer', based on what we observed within the data*.

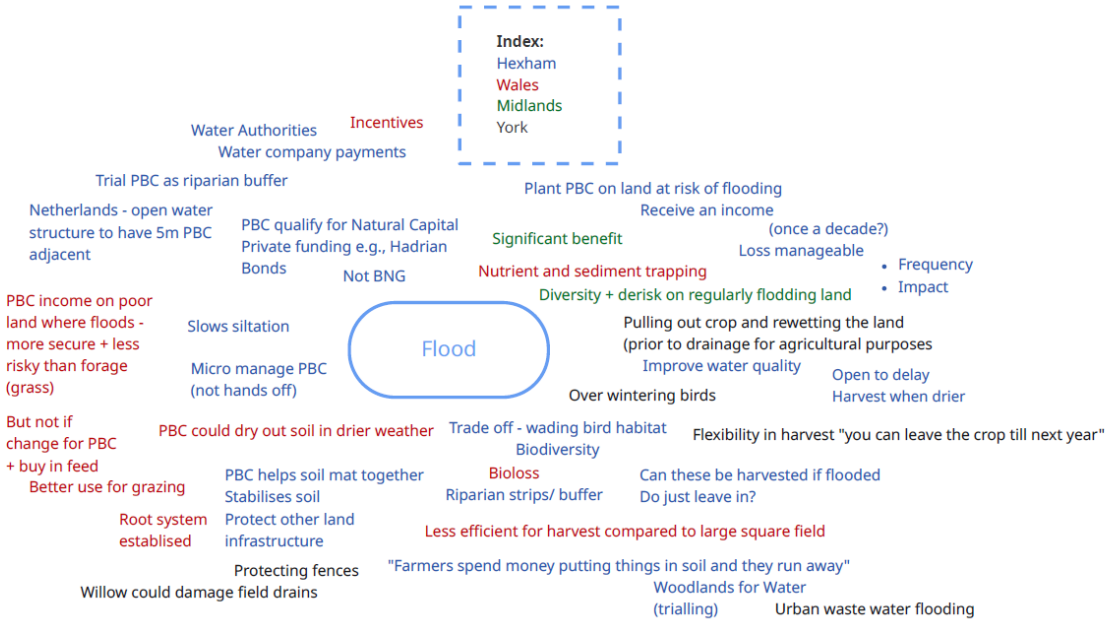
5. Have you seen others do this? Is it realistic?
6. What conditions / future mechanisms would need to be in place for this shift? / for you to make this shift?
    Prompts: such as new policy instruments (like SFI), natural capital markets
7. Where are there gaps in support?
8. What future opportunities have we missed? New markets? Community energy?
    Prompts: New policy instruments; ecosystem services; other natural capital revenue; other GGR options such as biochar
9. Have you seen farmers working together planting PBC or other land managers (estates, national parks etc) planting PBC at a landscape scale
10. Could they suggest other interviewees, such as other growers and farm advisers?

Appendix B

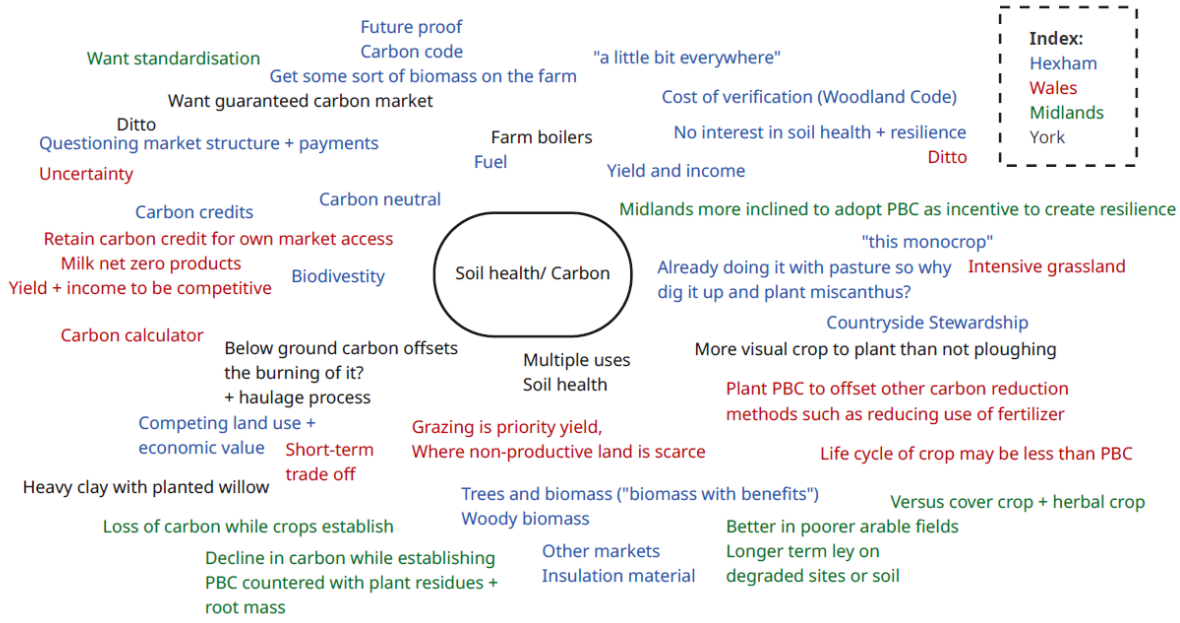
Analysis of Phase 2 data

Code cluster by PBC benefit – yield and farm business

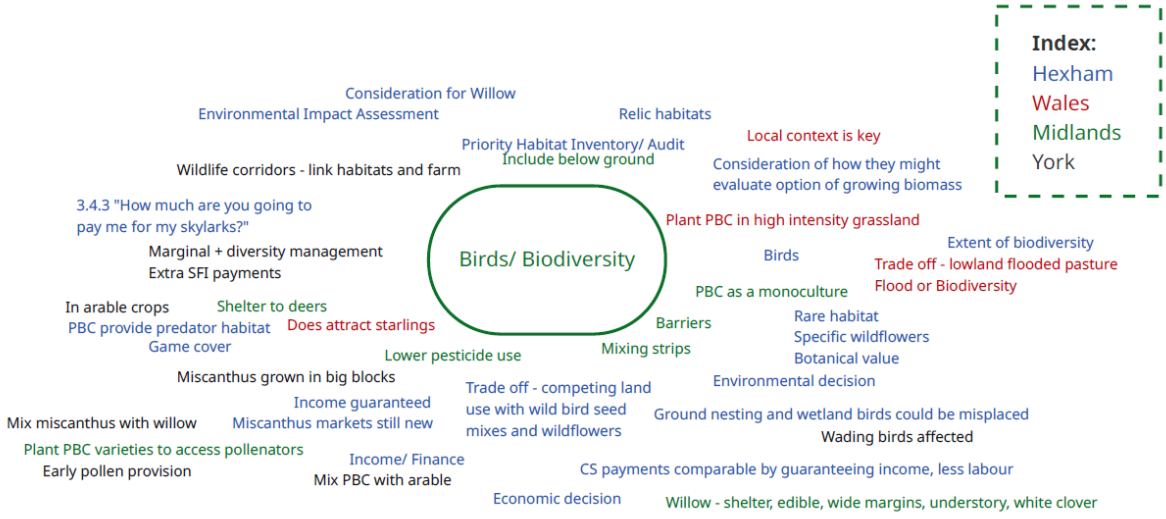
Code cluster by PBC benefit – flood mitigation



Code cluster by PBC benefit – soil health and carbon capture



Code cluster by PBC benefit – biodiversity



Appendix C

Clustering PBC goals against grower archetypes