Resource Recovery from Agricultural Waste

Nordic evidence and a transferable framework for livestock manure, crop straw and mulch film

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FOR THE LEARNER

What you will be able to do

1

Apply a five-question lens

Technology, economics, contaminants, acceptance and local fit: usable on any farm waste stream.

2

Explain why the “obvious” fix is conditional

Use Nordic evidence to show when recovery helps, and when it does not.

3

Design your own plan

A quantify, match, manage, verify approach for your region's streams.

Three streams today: livestock manure · crop straw · discarded mulch film

THE PRINCIPLE

Nothing here is only “waste”

Manure, straw and plastic film are resources in the wrong place or form. They clearly have value. The real question is whether recovering it pays off under local conditions.

P

Phosphate rock

Finite and on the EU critical raw materials list

C

Soil carbon

A climate lever large enough that small changes matter

⚠

“White pollution”

About 103 kg/ha average macroplastic in Chinese farm soils, up to 325

THE ANALYTICAL TOOL

One lens for every waste stream

1. **Technology** Can we recover it, and how?
2. **Economics & logistics** Does it beat mineral fertiliser once you move it?
3. **Contaminants & safety** Toxic elements, microplastics, antibiotics?
4. **Policy & acceptance** Are there incentives, and will farmers trust it?
5. **Local fit & proof** Does it work in this climate, and how do we know?

We run all three streams through these five questions.

A checklist you can reuse on any residue at home.

Framework: Cordeiro & Sindhøj (2024), Frontiers in Sustainability 5:1465752 (open access)

LIVE · MENTIMETER

Over to you

Name one “waste” produced by farms in your region.

Word cloud. No wrong answers; we will return to your words at the end.

Join at

menti.com

code

0000 0000

(insert your Menti code / QR)

STREAM 1 · LIVESTOCK MANURE

The right nutrients, the wrong place

The mismatch

Livestock regions build up a phosphorus surplus.
Cereal regions run a deficit and buy mineral P.

The resource exists, just not where it is needed.

The limit: manure is 85–95% water, so moving it can cost more than the nutrients are worth.

8.5

kg P / ha

Average phosphorus surplus across every Norwegian county. Redistribute manure P and Norway could be self-sufficient in phosphorus fertiliser.

Hanserud et al. (2016), Nutrient Cycling in Agroecosystems 104:307–320 (open access)

STREAM 1 · LIVESTOCK MANURE

Concentrate it, clean it, close the loop

Separate

Mechanical separation moves P into the solid fraction

Recover

Struvite precipitation and ammonia stripping capture N and P

Cut losses

Slurry acidification lowers ammonia emissions by over 80% in storage

Then ask Question 3, contaminants

Toxic elements, microplastics and antibiotic resistance genes are what actually block farmer adoption of recycled fertilisers, and are already a live research topic with China's Ministry of Agriculture and Rural Affairs.

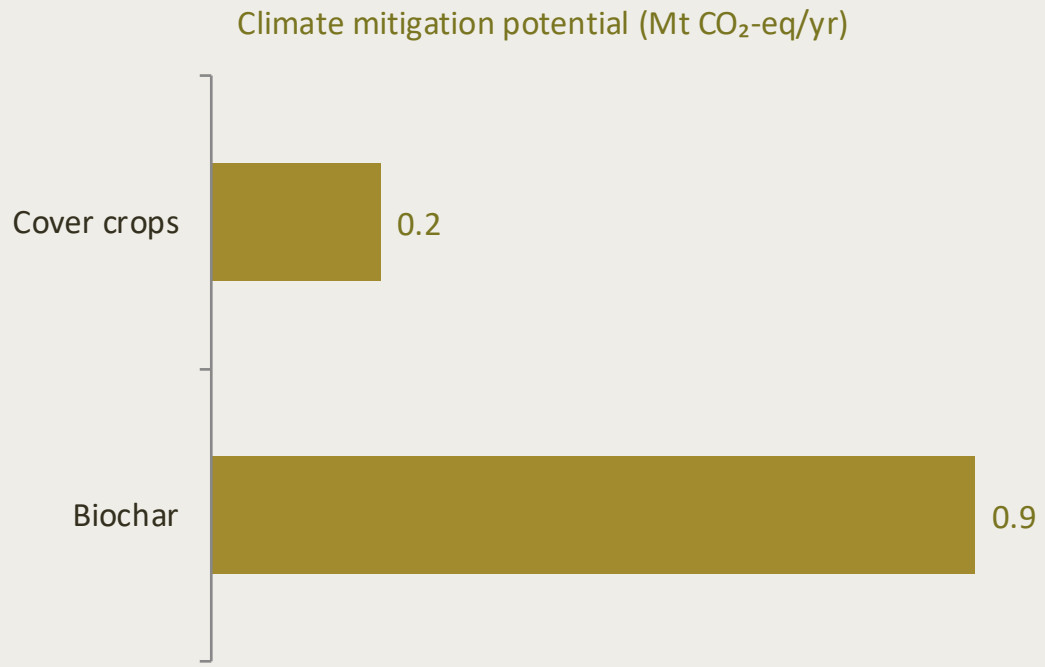
Bridge to Stream 2

The solid fraction can be pyrolysed into biochar: the same feedstock, a second valorization route.

Sindhøj & Rodhe (2013), Report 412 · Persson & Rueda-Ayala (2022) · Cordeiro & Sindhøj (2024) · Zhang et al. (2026)

STREAM 2 · CROP STRAW

A contested resource: match it to the soil



Biggest potential, but not ready

Biochar could offset about 20% of farm emissions; 25 to 50% of its carbon persists beyond 100 years. Yet cost still exceeds carbon-credit value.

Best all-rounder

Cover crops score highest on certainty and farmer adoptability.

Straw is finite and contested

About 0.49 Mt/yr available, and it competes with bioenergy.

Budai et al. (2024), European Journal of Soil Science: "not straightforward whether results elsewhere transfer to local conditions" (open access)

STREAM 3 · MULCH FILM

From “white revolution” to “white pollution”

Why farmers use it

It holds soil moisture and temperature, suppresses weeds, and raises yields, which is why China uses it at enormous scale.

Where it fails

Used film is contaminated with soil and costly to collect and recycle, so much goes to landfill or is left in the field, fragmenting into microplastics.

The marketed fix

Biodegradable film you can till straight in.

But does it actually degrade where you farm?

STREAM 3 · MULCH FILM

“Biodegradable” is a laboratory claim, not a field guarantee

52–93%

of biodegradable film mass was still in the soil after two years

Coutris et al. (2025) · 5 farms, Nordic soils

Fragments, does not vanish

It breaks into biodegradable microplastics along the way.

Cold climate means accumulation

Degradation needs warmth and organic matter, so repeated yearly use builds up.

Not automatically greener

LCA: fully-collected conventional film can have lower impact; biodegradable film plateaus in soil if reapplied too soon.

Coutris et al. (2025), Chemosphere 384:144516 · de Sadeleer & Woodhouse (2024), Int. J. LCA 29:275–290 (both open access)

PULLING IT TOGETHER

Two threads run through all three streams

1 · Biochar, the connective tissue

Manure solids and crop straw feed the same pyrolysis route. The streams are not three silos; they converge.

2 · Contaminants, the connective concern

Microplastics (from film and via digestate) and antibiotics (from manure) decide whether farmers and consumers will accept the product.

The potential is real, but always conditional.

The Nordic science measures the limit as carefully as it measures the promise. That discipline is the result.

Transfer the method, not the numbers

Cold-winter regions

Slow degradation raises the same film accumulation risk found in the Nordic trials.

Arid regions

Heavy reliance on mulch film for water, so a high residue load to begin with.

Livestock-dense regions

Manure phosphorus surpluses, so the redistribution logic applies directly.

Already underway

NIBIO researchers are co-authoring with China's Ministry of Agriculture and Rural Affairs institutes on livestock-waste treatment. This is a dialogue, not a lecture.

The deliverable: quantify → match → manage → verify

LIVE · MENTIMETER QUIZ

Quick check: three questions

Q1 **Norway could be self-sufficient in phosphorus using only its manure.**

True / False

Q2 **After two years in Nordic soil, how much biodegradable film remained?**

under 10% / about 25% / 50 to 90%

Q3 **Which soil-carbon method scored best on certainty AND farmer adoption?**

Biochar / Cover crops / Straw burial

menti.com · code 0000 0000 · answers revealed live (correct: True · 50 to 90% · Cover crops)

IF YOU REMEMBER FOUR WORDS

Quantify · Match · Manage · Verify

Quantify

Know the amount, and the contaminant load, before anything else.

Match

Fit the recovery route to your temperature, soil and timing.

Manage

Treat contaminants as the real barrier to adoption, not an afterthought.

Verify

Prove the benefit with local data before you scale.

Every stream is a resource; the job is to prove the benefit before you scale.

EVIDENCE BASE

Sources: open access unless noted

- Hanserud et al. (2016) Nutr. Cycl. Agroecosyst. 104:307–320
- Persson & Rueda-Ayala (2022) Front. Sustain. Food Syst. 6:993043
- Brod et al. (2017) Ambio 46:852–864
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- ECONUTRI (2024) Deliverable D7.2, practice abstracts

Nordic evidence carries the case; international studies situate it. Full DOIs in the accompanying speaker notes document.

Thank you · 谢谢

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Discussion: which of your region's waste streams do you know the quantity, and the contaminant load, of?

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