

Nutri2Cycle

D.2.2 Shortlist of solutions for further research

Deliverable:	Shortlist of solutions for further research
Author(s):	Erik Meers & Evi Michels (UGent)
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Co-ordinator:	Prof. Erik Meers, Ghent University
Contact details:	Erik.meers@ugent.be





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2. Introduction

The Nutri2Cycle project uses an integrated approach to enable the transition from the current (suboptimal) nutrient household in European agriculture to the next-generation of agronomic practices, characterized by an improved upcycling of nutrients and organic carbon. To achieve this a methodology was developed in which a logical flow is followed to identify, select and scrutinize the most promising scenario's for EU agriculture.

The NUTRI2CYCLE methodology is represented in the figure below. In a previous step (deliverable D2.1) a longlist of potential solutions was presented (step 1). The current deliverable represents step 2 in which we further prioritize these solutions to a manageable contingent of maximal 24 proposed (integrated) technical and management solutions for farming systems aimed at closing nutrient loops and efficient mitigation measures.



The NUTRI2CYCLE methodology for more efficient nutrient loops at the local, regional & European scale





In the innovation funnel a further evaluation and prioritisation of the longlist solutions was made into the current Shortlist. According to the Grant Agreement (GA) this selection should be based on the ability and potential to close N, P and C loops and their technological, environmental and economical validity. However, as this selection already had to be made by month 6, the required data on the solutions to make this assessment was still incomplete. Therefore, an alternative shortlisting procedure was used, which was based on the following criteria:

- A Pivotal Project Launch & Decision Bootcamp in Brussels on 21/01/2019 was organized with detailed partner discussion on the longlist (potential towards enhancing GHG footprint, reduce N and P losses, and/or improve soil organic carbon). This boot camp was a full physical gathering of the Nutri2cycle consortium, linked as a dedicated satellite event to the first Edition of the "European Sustainable Nutrient Initiative" conference (ESNI);
- Interlinkage with the different identified agro-typologies and investigated research lines within Nutri2Cycle;
- Expert assessment on availability and quality of existing data (e.g. building on previous projects) and access to infrastructure (research scalability / potential towards TRL-lift within the project time) to carry out further investigations of the proposed innovation in relevant conditions;
- A balanced geographic spread, as well as sufficient coverage of the 8 agro-typologies

This resulted in the selection of 45 of the longlist solutions, which were clustered into 24 sub-research lines, which has been described in Deliverable 2.2. The strategy to work around 24 sub-research lines is another rationalisation in the selection and categorization process: rather than identify 24 loose and independent solutions the consortium chooses to pursue investigations along 45 of the original long-listed solutions but to cluster them into workable categorizes which themselves link to the 5 over-arching research lines. Essentially, the selection and categorization of solutions therefore follows the following "taxonomy": 5 research lines > 24 sub-research Lines > 45 single investigations.

This shortlist of solutions formed the basis for the feasibility assessment for the emission modelling and the LCA selection. For these shortlisted solutions data was acquired from the agro-technical research in WP2, which has been described in Deliverables 2.3 and 2.4. These Deliverables contain an elaborated description expanding beyond the description of the original Factsheets compiled in D.2.1. In addition, the consortium will commit to gather further quantified data from the agro-technical research (WP2) of which the results will be compiled in a new Deliverable 2.6. (not originally foreseen in the Grant Agreement) more towards the end of the project.

This prioritization forms the basis for theoretic and practical research activities of the consortium towards successive environmental, micro and macro-economic and human factor evaluation and further scrutinizing towards demo development.





3. Shortlist of solutions for further research

The following prioization could be established. For comprehensive understanding as well as linking the proposed solutions to the NUTRI2CYCLE work plan, we have further subdivided them over the 5 technical research lines of the project.



On the next page, we have listed the 24 subresearch lines that were defined based on the expert bootcamp associated to the first ESNI conference, clustered under the 5 over-arching research lines as defined in the Nutri2cycle project GA (and illustrated in the Figure above).

On the subsequent pages thereafter, the (45) specific single solutions linked to each of these reseach lines & sub research line is tabled in further detail, with expanded information on the Longlist solution ID number, title, country, responsible partner, current TRL, allocated Tier (subdivided in Tier 1 and Tier 2 for phased investigation within the project), availability of economic information, willingness to collaborate & share samples, suitability to conduct LCA either in Tier 1 or Tier 2.





Category		Shortlist N°	Shortlist - Title
Innovative soil, fertilis management systems	ation & crop & practices	1	Practices for increasing soil organic matter content
for enhanced N,P eff	iciency and	2	Catch crops to reduce N losses in soil and increase biogas production by
increased soil OC	content		anaerobic co-digestion
	Substituting primary	3	Substituting external mineral nutrient input from synthetic fertilisers by recycled organic based fertilizers in orchards & agroforestry
	resources by biobased	4	Substituting external mineral nutrient input from synthetic fertilisers by recycled organic based fertilizers in arable farming
Substituting primary	products in practice	5	Blending of raw and treated organic materials to produce organic fertilisers or growth substrates
biobased products	Engineering	6	P recovery from organic waste(water) streams via struvite crystalization
	nutrient recovery	7	Pig manure processing and replacing mineral fertilizers
	processes	8	P recovery from animal bones
		9	Insect breeding as an alternative protein source on solid agro-residues (manure and plant wastes)
Novel animal feeds pro	oduced from	10	Domestic cultivation of protein crops
agro-residue	S	11	Utilization of crop residues in animal feed
		12	Floating wetland plants grown on liquid agro-residues as a new source of proteins
		13	Anaerobic digestion strategies for optimized nutrient and energy recovery from animal manure
		14	Tailor made digestate products (tool development)
Innovative manageme tools & practices for	ent systems, optimized	15	Organic matter recovery from manure and associated valorisation strategies
nutrient and GHG ma animal husba	ngement in ndry	16	Use of an inoculate of microbiota and enzymatic pre-cursors to reduce ammonia emissions and optimize nutrient use efficiency in poultry manure
		17	Slurry acidification to reduce NH3 volatilisation from animal production
		18	Nutrient mass flow analysis to better map and understand NPC flows at farm level
		19	Precision farming coping with heterogeneous qualities of organic fertilizers in the whole chain
		20	Field assessment of precision fertilization of maize & cereals using bio-based fertilizers
Tools, techniques & s	systems for	21	Field assessment of of precision arable farming using bio-based fertilizers in potato growing
higher-precision fe	tilization	22	Integration of UAV/Drone and optical sensing technology into pasture systems
		23	Near Infrared Sensors for more insight on actual nutrient concentrations in organic fertilisers with variable composition
		24	Nitrogen sensor technology to make real-time crop assessment



Research Line	Sub-research Line (Shortlist Title)	Long- list N°	Long-list Abstract Title	TRL	Tier	Country	background economic data ✓	samples & collobration	Partner 🗸	Research for LCA by M 16 (Tiers 1) ▼	Research for LCA by M 20 (Tier 2 <mark>)</mark>
1.Innovative solutions for optimized nutrient & GHG in animal husbandry	13. Anaerobic digestion strategies for optimized nutrient and energy recovery from animal manure	10	Small / Farm scale anaerobic digestion of agroresidues to increase local nutrient cycling & improve nutrient use efficiency	6-2	2	Belgium	٢	۲	INAGRO	to be verified	to be verified
 Innovative solutions for optimized nutrient & GHG in animal husbandry 	 Anaerobic digestion strategies for optimized nutrient and energy recovery from animal manure 	48	Recovery of energy from poultry manure and organic waste through anaerobic digestion	e	1	Poland	7	7	PCz	ON	YES
 Innovative solutions for optimized nutrient & GHG in animal husbandry 	14. Tailor made digestate products (tool development)	61	Tailor made digestate products (tool development)	4	1	Belgium			UE	ON	PARTLY
1.Innovative solutions for optimized nutrient & GHG in animal husbandry	15. Organic matter recovery from manure and associated valorisation strategies	11	Recycling fibres of manure as organic bedding material for dairy cows	9	1	Belgium	۲	۲	INAGRO	to be verified	to be verified
1.Innovative solutions for optimized nutrient & GHG in animal husbandry	 Organic matter recovery from manure and associated valorisation strategies 	24	Adapted stable construction for separated collection of solid manure and urine in pig housing (followed by separate post- processing)	6	2	Belgium	٢	۲	UG/INAGR O	ON	YES
1.Innovative solutions for optimized nutrient & GHG in animal husbandry	 Organic matter recovery from manure and associated valorisation strategies 	8	Acid leaching of P from organic agro-residues in order to produce OM-rich soil enhancers and P-fertilizers	9	1	etherlands	۲	7	WUR	ON	YES
 Innovative solutions for optimized nutrient & GHG in animal husbandry 	and enzymatic pre-cursors to reduce ammonia emissions and optimize nutrient use efficiency in poultry manure	27	Use of an inoculate of microbiota and enzymatic pre-cursors to reduce ammonia emissions and optimize nutrient use efficiency in poultry manure	7	2	Spain	۲	7	CARTIF	ON	YES
1.Innovative solutions for optimized in nutrient & GHG in animal husbandry	 Slurry acidification to reduce NH3 volatilisation from animal production 	18	Slurry acidification with industrial acids to reduce NH3 volatilisation from animal husbandry	6	2	Denmark	٢	۲	ИСРН	YES, review data available	NO
1.Innovative solutions for optimized nutrient & GHG in animal husbandry	 Slurry acidification to reduce NH3 volatilisation from animal production 	19	Slurry bioacidification using org. waste products to reduce NH3 volatilisation and increase fertiliser value	2	1	Denmark		7	ИСРН	ON	Vo, due to maternity leave for dr. Carrera Nov 2019-Nov 2020, results for bioacidification will not be available until at the earliest month 36 (Nov 2021)
1.Innovative solutions for optimized nutrient & GHG in animal husbandry	18. Nutrient mass flow analysis to better map and understand NPC flows at farm level	32	Annual Nutrient Cycling Assessment (ANCA)	8- <mark>0</mark>	2	The etherland s	7	7	ZLTO	depends on what is needed	depends on what is needed

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Research Line	Sub-research Line (Shortlist Title)	Long- list N°	Long-list Abstract Title	TRL	Tier 🗸	Country	background economic data ✓	samples & collobration	Partner •	Research for LCA by M 16 (Tiers 1) 🗸	Research for LCA by M 20 (Tier 2 <mark>)</mark>
2.Innovative soil, fertilisation & crop management systems & practices	 Practices for increasing soil organic matter content 	16	Using digestate, precision agriculture and no-tillage focusing on OM stocking in an area characterize by the lack of OM in sandy soil	6	2	Italy	7	7	NMIL	No	YES
2.Innovative soil, fertilisation & crop management systems & practices	 Practices for increasing soil organic matter content 	17	Crop farmer using a variety of manure and dairy processing residues to recycle and build soil C, N, P fertility	9	1	Ireland	۲	۲	TEAGASC	N	YES
2.Innovative soil, fertilisation & crop management systems & practices	 Practices for increasing soil organic matter content 	71	Practices for increasing soil organic matter content in Dutch soils	7	2	letherlands		٢	WUR	ON	YES
2.Innovative soil, fertilisation & crop management systems & practices	 Catch crops to reduce N losses in soil and increase biogas production by anaerobic co-digestion 	21	Catch crops to reduce N losses in soil and increase biogas production by anaerobic co-digestion	و	1	Spain	r	7	IRTA	ON	YES





Research Line	Sub-research Line (Shortlist Title)	Long- list N°	Long-list Abstract Title	TRL V	Tier	Country	background economic data <mark>v</mark>	samples & collobratio <mark>n</mark>	Partner •	Research for LCA by M 16 (Tiers 1)	Research for LCA by M 20 (Tier 2)
3.Tools, techniques & systems for higher-precision fertilization	 Precision farming coping with heterogeneous qualities of organic fertilizers in the whole chain 	30	Precision farming coping with heterogeneous qualities of organic fertilizers in the whole chain	6	2	Germany	٢	7	THU	YES	YES
3.Tools, techniques & systems for higher-precision fertilization	20. Field assessment of precision fertilization of maize & cereals using bio-based fertilizers	28	Precision farming and optimised application: unter-root application of liquid manure for maize and other row crops	80	2	Germany	۲	7	THU	YES	YES
3.Tools, techniques & systems for higher-precision fertilization	20. Field assessment of precision fertilization of maize & cereals using bio-based fertilizers	63	Precision fertilization of Maize using organic materials	4-5	1	Portugal	٢	7	ISA	ON	ON
3.Tools, techniques & systems for higher-precision fertilization	21. Field assessment of of precision arable farming using bio-based fertilizers in potato growing	73	Precision arable farming using bio-based fertilizers in potato growing	5-6	1	the letherland s	۲	7	ZLTO	depends on what is needed	depends on what is needed
3.Tools, techniques & systems for higher-precision fertilization	22. Integration of UAV/Drone and optical sensing technology into	68	Integration of UAV/Drone and optical sensing technology into pasture systems	3	1	Ireland	۲	۲	TEAGASC	ON	NO
3.Tools, techniques & systems for higher-precision fertilization	24. Nitrogen sensor technology to make real-time crop assessment	13	Sensor technology to assess crop N status	9	1	Hungary	7	7	SOLTUB	ON	YES
3.Tools, techniques & systems for higher-precision fertilization	24. Nitrogen sensor technology to make real-time crop assessment	76	Nitrate sensor for optimal grassland management	S	1	etherlands			ZLTO	depends on what is needed	depends on what is needed





	Research Line	Sub-research Line (Shortlist Title)	Long- list N°	Long-list Abstract Title	TRL 1	ier C	ountry •	background economic data ✓	samples & collobration	Partner 🗸	Research for LCA by M 16 (Tiers 1) 🔽	Research for LCA by M 20 (Tier 2 <mark>)</mark>
	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 Substituting external mineral nutrient input from synthetic fertilisers by recycled organic based fertilizers in orchards & agroforestry 	66	Application of digestate in large scale orchards	6-8	5	croatia	7	7	Sal	part of data	YES
	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 Substituting external mineral nutrient input from synthetic fertilisers by recycled organic based fertilizers in orchards & agroforestry 	57	Recovered organic materials and composts for precision fertilization of apple orchards and vineyards	~	5 P	ortugal	7	7	ISA	Q	YES (MAYBE)
	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 Substituting external mineral nutrient input from synthetic fertilisers by recycled organic based fertilizers in orchards & agroforestry 	15	Closing the loops at the scale of farm : using the livestock manure to fertilize the feeding crop on agroforestry plots	7	5	rance	7	۲	CA17	YES	YES
	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 Substituting external mineral nutrient input from synthetic fertilisers by recycled organic based fertilizers in orchards & agroforestry 	14	Substituting mineral inputs with organic inputs in organic viticulture	9	-	rance	r	٢	CA17	YES	YES
	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	4. substituting external minieral nutrient input from synthetic fertilisers by recycled organic based fertilizers in arable farming	1	Ammonium stripping / scrubbing and NH4NO3 as substitute for synthetic N fertilizers	7	2 E	elgium	7	٢	UG/INAGR O	ON	YES, results of year 1
	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 Substituting external mineral nutrient input from synthetic fertilisers by recycled organic based fertilizers in arable farming 	2	Ammonium stripping / scrubbing and NH4SO4 as substitute for synthetic N fertilizers	6	2 E	elgium	7	7	UG/INAGR O	ON	YES, results of year 1
tl re u	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	nutrient input from synthetic fertilisers by recycled organic based fertilizers in arable farming	9	Concentrate from vacuum evaporation/ stripping as nutrient-rich organic fertilizer	4	1	elgium	۲	۲	NG	ON	ON
ne Europ esearch nder grar	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	nutrient input from synthetic fertilisers by recycled organic based fertilizers in arable farming	6	Liquid fraction of digestate as a substitute for mineral N & K fertilizer	7-9	2 E	elgium	7	7	UG/INAGR O	Q	YES, results of year 1
ean Uni and inno agreem	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 Blending of raw and treated organic materials to produce organic fertilisers or growth substrates 	62	Blending of raw and treated organic materials to produce organic fertilisers (NPC)	3-4	1	ortugal		7	ISA	Q	YES (MAYBE)
on's Hor ovation p ent No 7	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 Blending of raw and treated organic materials to produce organic fertilisers or growth substrates 	47	Production of growing substrates for horticulture application from poultry manure, solid state digestate and biochar through composting	m	-	oland	7	٢	PCz	Q	ON
rizon progra 73682	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 P recovery from organic waste(water) streams via struvite 	65	Struvite as a substitute of synthetic P fertilizer	4	1	elgium	7	7	DG	YES	YES
2020 mme	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 P recovery from organic waste(water) streams via struvite 	49	Nitrogen and phosphorus recovery from pig manure via struvite crystallization and design of struvite based tailor-made fertilizers	9	1	Spain	7	7	CARTIF	ON	YES
P	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 P recovery from organic waste(water) streams via struvite crystalization 	52	Pilot-scale crystallizer for P recovery	4	1	Italy		۲	NMIL	YES	YES
age 1	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	 Pig manure processing and replacing mineral fertilizers 	23	Pig manure refinery into energy (biogas) and fertiliser using a combination of techniques applicable at industrial pig farms	6	2	Italy	7	۲	NMIL	ON	YES
0 of	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	7. Pig manure processing and replacing mineral fertilizers	55	Manure processing and replacing mineral fertilizers in the Achterhoek region	7	2 Ne	therland		٢	WUR	ON	YES
11	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	7. Pig manure processing and replacing mineral fertilizers	20	Low temperature ammonium-stripping using vacuum	4	1	Spain		7	IRTA	ON	YES
	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	7. Pig manure processing and replacing mineral fertilizers	43	Pig manure evaporation plant	4-5	1 Ne	therland	7	7	ZLTO d	lepends on what is needed	depends on what is needed
	4.Biobased fertilisers (N, P) and soil enhancers (OC) from agro-residues	8. P recovery from animal bones	22	BIO-PHOSPHATE: high temperature reductive thermal process recovery of concentrated Phosphorus from food grade animal bones	8-9	2	ungary	7	7	Ħ	ON	YES

Research Line	Sub-research Line (Shortlist Title)	Long- list N°	Long-list Abstract Title	TRL <	Tier V	Country	background economic data 🗸	samples & collobration	Partner 🗸	Research for LCA by M 16 (Tiers 1)	Research for LCA by M 20 (Tier 2)
5.Novel animal feeds produced from agro-residues	 Insect breeding as an alternative protein source on solid agro-residues (manure and plant wastes) 	40	insect breeding as an alternative protein source on solid agro- residues (manure and plant wastes)	7	2	Belgium	7	7	INAGRO	ON	YES
5.Novel animal feeds produced from agro-residues	10. Domestic cultivation of protein crops	25	Soybeans in Poland - innovative solutions in the cultivation, plant protection and feeding on farms	4	1	Poland	٢	٢	PcZ	ON	ON
5.Novel animal feeds produced from agro-residues	10. Domestic cultivation of protein crops	45	INPULSE: Innovating towards the use of Spanish legumes in animal feed	ć	ć	Spain	7	٢	CARTIF	ON	ON
5.Novel animal feeds produced from agro-residues	11. Utilization of crop residues in animal feed	34	Secondary harvest: additional valorisation of crop harvest and processing residues	۰.	¢.	Belgium	۲	7	INAGRO	ON	ON
5.Novel animal feeds produced from agro-residues	12. Floating wetland plants grown on liquid agro-residues as a new source	41	Floating wetland plants grown on liquid agro-residues as a new source of proteins	9	1	Belgium	۲	٢	UG/INAGR O	ON	YES
5.Novel animal feeds produced from agro-residues	24. Algae grown on liquid agro- residues as a new source of proteins	۰.	Algae grown on nutrient rich liquid agro-effluents as a new source of proteins	4	1	Belgium			NG	ON	YES



