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End report

In collaboration (dairy and arable farmers) profitable, regional, and regenerative farming (3xR)

Phase 1: Feasibility study

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Executive summary

“From business-driven collaboration to soil-driven collaboration”

The 3XR project aims to address the challenges faced by the agricultural sector due to negative impacts of current farming practices. This project takes a comprehensive approach, driven by regenerative concepts, to transform the current farming system with negative environmental consequences into a regenerative farming system that positively contributes to food production while benefiting the environment.

It has been explored whether the collaboration between crop farmers and dairy producers could be a cornerstone for this transition, fostering circular and regenerative practices.
Co-initiated by farmers, phase 1 of this project operated through co-creation with them. The ultimate goal is to establish a viable regional collaboration between crop and dairy farming that manifests as a regenerative agricultural system, guided by a scientific "set of requirements.
The key objectives are improving the income of farmers by 15%, achieving climate-neutral food production, self-sufficiency in feed, fertilizers and energy.

Using scientific knowledge, a scalable dashboard with relevant KPIs has been developed, aiming to calculate and visualize the impact of measures needed to move towards a more regenerative agriculture system.

Implementation of phase 1 of this initiative involves selecting two distinct types of collaborative partnerships between dairy and arable farming. In co-creation with these farmers, the concept of collaboration is further developed in a way that suits the relevant practical situations. In this project, it was investigated whether full integration of forage and arable crops, based on existing acreage, is feasible in practice. And how a joint crop rotation- and soilplan can be designed, with a focus on long-term soil health. What will be the impact on the income of the farmers, and does it provide solutions to the current challenges farmers are facing, including (further) improving the carbon footprint, reducing emissions, decreasing the use of pesticides, and enhancing soil health?

The outcome of this exploration indicates that it appears feasible to implement a full integrated cropping and soil plan while maintaining the same income. The calculation of all measures shows a potential improvement on climate, soil health and nature-related metrics. Two cases show a potential reduction of carbon footprint (20% - 30%), reduction of ammonia emissions (6%-10%) and a reduction of nitrogen and phosphate surplus (100%) in 5 years. See example of results in figure 1.
The results also show that the proposed measures in the medium and long term are still insufficient to become fully climate-neutral, additional measures are needed for that. In the long-term scenario of case 1, where the rotation plan and the production of milk will be more extensive, resulting in better score in terms of carbon footprint and emissions, the farmers balance becomes negative compared to the current situation. The positive environmental aspects (and the additional costs incurred for them) are not yet adequately reflected in market prices.

The advantages for the arable farms would be:
- Reduction of chemical inputs: manure from dairy farm replaces synthetic fertilizers
- Increasing knowledge about the composition of manure and ensuring access to cattle manure.
- Improvement of soil health: increase in soil organic matter, soil quality, soil physical condition, higher water retention (resistance to drought) and increase in soil biodiversity (resistance to pests)
- Climate mitigation: improvement of soil carbon sequestration through uptake of more grassland in the rotation plan.
- Reduction of nutrient leaching: grassland/pastures reduce N leaching
- Reduction of weeds: through crop-pasture rotation
- Understanding soil health per field provides the opportunity for a better cropping plan and more targeted measures.

The advantages for the dairy farms would be:
- Reduction of feed inputs: reduction in environmental footprint from external feed inputs, I.e.. Most feed that is fed to the dairy herd is produced in cooperation with the arable farmer enhancicng "land-based" farming.
- Cutting weeds/pests cycles: Through crop-pasture rotation inoculum from weeds and pests are removed.
- Better use of manure: Valorization of nutrients in products
- Circular manure use, no/less export of manure from the farming system
- Different perspective than growing on margins in milk but on diversifying

In addition to the improvements in KPIs and the benefits for farmers, there are certainly disadvantages:
- Increase in management and coordination complexity
- Higher initial costs than under single specialized operations
- Financial risks during the transition phase (risk of crop yield loss during the reduction of pesticides, risk of problems with the health of the cows or the production of milk as a result of a changed feed management)
- Complex grassland management (dilemmas regarding permanent grassland)

The involved farmers demonstrate willingness and motivation to implement (parts of) a joint cropping and soil plan. However, given the need to maintain the same income on the one hand and the increase in risks and complexity on the other hand, financial support (or guarantees) is required to make this step a reality.
Figure 1 visualizes the concept, figure 2 shows the impact on key KPIs.

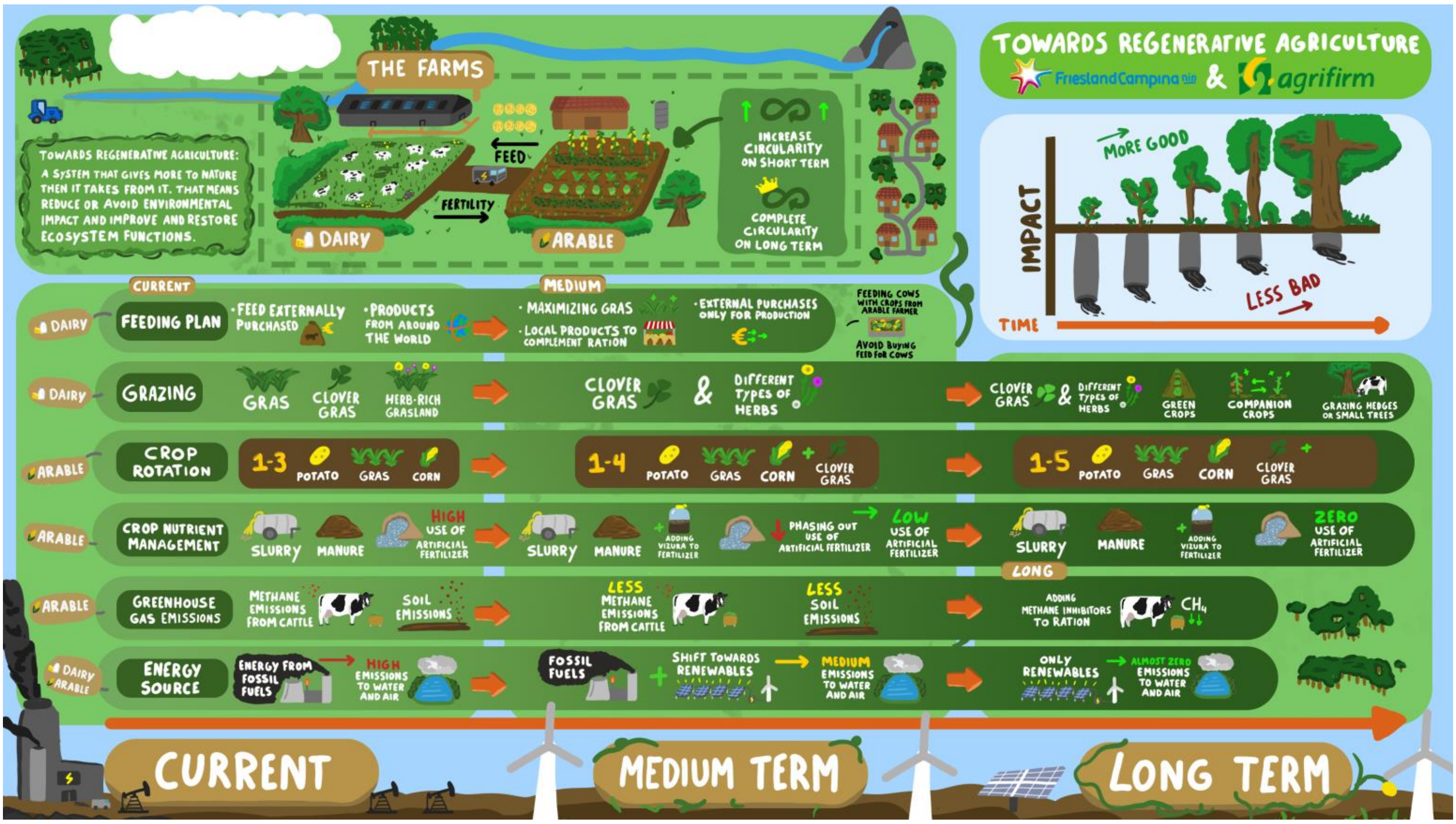


Figure 1: Concept of collaboration arable and dairy farm

Figure 2: Visualization results KPI's

Content

Background and goal

Background 3XR

For decades, agriculture has been focused on improving production efficiency which has led to undesirable side effects of current agricultural production systems. Globally, measures are being rapidly implemented to minimize these side effects. Specific goals vary by continent/country/region, often depending on local societal trends.

In addition to this global trend, a unique and pioneering situation seems to have emerged in the Netherlands. While the post-World War II directive in the Netherlands was straightforward (never hunger again), the current situation appears to be so broad and complex that consumers, governments and farmers are increasingly struggling to find and implement the right measures.

This line of thinking translates into a systemic approach in this project. Based on regenerative concepts, the aim is to transform the current system with high production but negative impacts on the environment, nature, and surroundings into a system that positively contributes to food and fiber production with a positive impact on the environment. This regenerative system will be measurable (to comprehensively assess its effects), scalable (to achieve the desired impact), profitable (as a prerequisite for our farmers), and will entail collaborations between arable and livestock farmers (to make it circular/regenerative).

This project is initiated by farmers and is being carried out in co-creation with them.

Goal 3XR

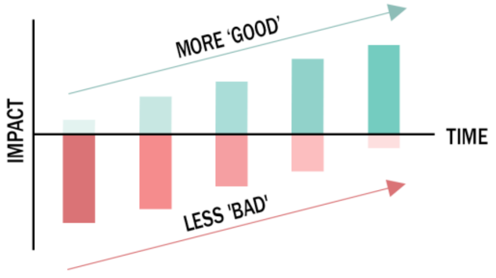
The ultimate goal is to develop a profitable regional collaboration between arable farming and dairy farming that leads to a regenerative agricultural system based on a scientifically determined "set of requirements."
This objective translates into the following sub-goals:

- Improve the profitability model by 15% through arable farming and dairy farming collaborations, partly by removing rotation restrictions through a jointly supported cultivation plan.
- Achieve net climate-neutral food production (cradle to farmgate) through:
    - Maximal greenhouse gas emission reduction with currently known and future oriented measures,
    - Maximize carbon sequestration in a vital soil, achieved by maintaining a good balance between chemical, physical, and biological measures combined with more comprehensive cultivation plans
    - Emission reduction (deposition and leaching) into air, (subsurface and surface) water, and soil.
- Achieve self-sufficiency (>90%) in roughage and concentrate feed for dairy cows through regional production in the cooperation of dairy and arable farming supplemented with the use of byproducts (for example beet pulp).
- Achieve self-sufficiency (>90%) in fertilizers through the application of products from manure processing combined with nitrogen fixation from the air using green energy, and the use of leguminous crops for both arable and dairy farming.
- Achieve a maximum level of energy self-sufficiency (100%) through production, and use of renewable energy (ammonia and hydrogen) on primary farms (solar, wind, manure), and if possible, become a net supplier of energy surplus.

Regenerative Agriculture

Concept regenerative agriculture

- Regenerative agriculture is a system that gives more to nature then it takes from it.
- that means to reduce or avoid environmental impact and to improve and restore ecosystem functions (desired outcomes).



Regenerative agriculture – the soil is the base (Schreefel et al., 2020):
"Regenerative agriculture focuses strongly on the environmental dimension of sustainability, which includes themes such as enhance and improve soil health, optimize resource management, alleviate climate change, improve nutrient cycling and water quality and availability. These themes enhance food security by contributing to provisioning (e.g., food, feed and fiber), regulating (e.g., climate regulation, soil erosion and water purification) and supporting (e.g. nutrient cycling and soil formation) ecosystem services".

Soil is the base - from antibiotic agriculture to pro-biotic agriculture:

Soil life is capable of nourishing the plant from the total pool of nutrients.

The plant can thrive without inputs.

Plan 3XR and objective phase 1

Regenerative agriculture is not an unfamiliar phenomenon among the farmer members of Agrifirm and FrieslandCampina involved in this project. Farmers have formed numerous ideas and conducted extensive explorations. These appear promising, but due to the complexity of regenerative agriculture, they are currently not leading to sufficient (pilot) implementations. Often, the financial risk for entrepreneurs is too high, there is a specific knowledge gap in certain areas, regulations are obstructive, making it difficult for individual farmers to create experimental space, there is insufficient trust in intended collaborations outside their own sector, or a technical initial implementation simply requires further development (volume production) to achieve significant cost reduction.
This project begins with this farmer-driven motivation for impact and aims to transition existing explorations into an implementation phase. Therefore, this project explicitly does not start from (scientific) model development that may potentially be applied on the farm later but rather stems from intrinsic farmer motivation. However, determining the boundaries of regenerative agriculture and whether farmer initiatives contribute to them requires measurability and substantiation. Therefore, scientific knowledge developed in the TIFN project, biodiversity monitors for Dairy and Arable Farming, the international chain project SAI (regenerative agriculture platform), and the KPI-K project (Dutch government circular agriculture) are utilized, among others.
In this project, the feasibility of potential implementation scenarios is assessed.
The following diagram and explanation outline the approach:

Objective phase 1 - 3XR

This project has been initiated based on this farmer-driven motivation for impact and aims to transition existing explorations into an implementation phase.
The objective of phase 1 is to perform a feasibility study of regenerative agriculture by cooperation of a dairy and arable farm.
The feasibility study has mapped out the opportunities and risks. Combined with the investment plan, it provides a comprehensive overview to make a rational decision regarding the subsequent phases.
This feasibility study has examined and analyzed the potential for implementation, with the aim of supporting decision-making by objectively and rationally assessing the strengths and weaknesses, opportunities, and risks of a project. It also indicates the resources needed to carry out the project and ultimately the chances of success.

During phase 1, some produced knowledge (for example the KPI manual and the calculation model) is foreground knowledge that will stay within the collaborative partners FrieslandCampina and Royal Agrifirm Group.

Implementation of activities phase 1 3XR

Activities and schedule phase 1

Main activity 1 - Selection of 2 initiatives:

1. Comprehensive overview of current Initiatives: surveying existing initiatives through district boards.
2. Bottleneck analysis: For each initiative, a bottleneck analysis will clarify why the initiative is not progressing and how this could be addressed within Fascinating.
3. Selection of 2 initiatives: Criteria will be established for the selection, with a crucial focus on their contributions to the regenerative objectives of this project. Scalability will also be a significant criterion. The selected initiatives will, at the very least, distinguish themselves based on region-specific conditions, especially soil type.

Main activity 2 - Concept development:

1. Regional & Regenerative Concept Development: In collaboration with the involved farmers of the 2 initiatives, concept development will take place. This concept will highlight the integrated components of regenerative agriculture, including their Key Performance Indicators (KPIs).
2. Development of a Scalable Dashboard: The impact of the regenerative system will be monitored through a dashboard. This can be partly structured based on scientific insights and partly based on real-time data from sensors. The goal is to develop a scalable dashboard, allowing it to be used for scaling up to other groups of farmers who opt for a different implementation of a regenerative farming plan or have different soil types.
3. Business Model: The collaboration should prioritize farmer returns from day one. Since a collaboration leading to regenerative agriculture is likely to involve a circular approach, new products and services may emerge, which might currently be carried out by external entities (such as Agrifirm and FrieslandCampina). Therefore, it is crucial to make well-informed decisions regarding fair compensation for products and services, as well as profit-sharing. This also applies to the legal aspects of these arrangements.
4. Pilot Investment Plan: This phase will conclude with an investment plan. Within this project, a budget has been allocated proportionate to the first-mover risk. In other words, we expect the initiatives to take on entrepreneurial risk, but risks that are too significant will be covered by the Fascinating project.

Planned Duration: 12 months.

Explanation of any deviations from the schedule and activities.

the project was carried out according to plan.

Results

Selection of 2 Initiatives

Based on the developed KPIs, the established selection criteria, and the overview of potential collaborations with dairy farmers and arable farmers in Groningen, 2 practical situations have been selected. Deliberate efforts were made to choose 2 entirely different but commonly found profiles of dairy and arable farming enterprises. These enterprises are located in different regions in terms of soil type (clay versus peat colony area) and vary in terms of dairy farming intensity (cows/ha) and cropping plan intensity (unit).
In addition to various substantive criteria, the intrinsic motivation of the respective entrepreneurs was an important prerequisite for the selection.

Ultimately, 2 combinations of arable farming and dairy farming (initiatives) have been selected. It is estimated that this combination can achieve, through closer collaboration focused on regenerative agriculture, greater self-sufficiency in terms of feed, energy, and fertilizers. Additionally, it is expected that this collaboration will result in economic benefits for both enterprises.

<u>Case 1: Partnership; combined enterprise - mainly clay soil</u>
Case 1 is a combination of an arable farm and a dairy farm with the following relevant characteristics, primarily on clay soil:

Arable Farming with an average cropping plan; 1 in 3, including seed potatoes (grass - seed potatoes - corn/grass/cereals/beans).

Dairy Farm;

- 100 dairy cows - 65 young cattle
- Farm size: 123 hectares
- Conventional fertilization (manure separation, slurry, artificial fertilizers), regular use of crop protection agents, and concentrate feed.

<u>Case 2: Dairy farmer in peat colony area, land exchange (sugar beet & silage maize) with 3 arable farmers</u>
Case 2 is a combination of 3 arable farms and a dairy farm in a peat colony area with various types of soil and regular rotation plan with potatoes.

Dairy Farm:

- 240 dairy cows - 175 young cattle
- Various soil types: field podzol soil, peaty soil, and partially clayey soil
- Farm size: 97 hectares
- Average cropping plan: grass - maize (sugar beet and starch potatoes rented out).
- Conventional fertilization (manure separation, slurry, artificial fertilizers), regular use of crop protection agents, and concentrate feed.

Dashboard Development

Set of requirements / KPI's

In the document *"Attachment 1; Report 3XR KPI",* the development of the set of requirements is extensively described. It includes an overview of the concept, the advantages and disadvantages of integrating dairy and arable farming enterprises, and then the definitions and descriptions of the KPIs used for this project.

Below is a brief overview of the selected KPIs:

Reduce and avoid:

- Climate
  - Greenhouse gas emissions (CO_2 eq)
- Air
  - Ammonia (NH_3/ha) emissions
- Water
  - Water pollution with nitrogen
  - Water pollution with phosphate (P_2O_5)
  - Water consumption
- Nature
  - Pesticide use
  - Disturbance from land use change - Percentage of protein from own land (%)
  - Disturbance from land use - Percentage of covered soil (%)
- Soil
  - Soil compaction

Improve and restore:

- Climate
  - Soil carbon stock and sequestration
  - Use of renewable energy (instead of fossil)
- Soil (Soil health)
  - Permanent grassland
  - Crop diversity
  - Tillage index
  - Percentage of rest crops
- Nature
  - Herb-rich grassland
  - Landscape elements
- Soil Health (plot level)
  - Total microbial mass
  - Organic matter
  - Mineral Plant availability
  - Worm population
  - Aggregate Stability
  - Plant health – dissolved solids

Preconditional:

- Animal Welfare and Health
    - Welfare and health of cattle
    - Welfare and health of cows
    - Longevity of cow life
    - Use of antibiotics
- Farmer Income – Saldo integration dairy and arable farm.

<u>Manual</u>

In addition to developing and selecting the right KPIs, an extensive manual has been developed within this project, which describes how each KPI can be calculated in practice. This includes details on the various data systems and how to utilize them. This manual is available within Agrifirm and FrieslandCampina.

<u>Development of the Business Model</u>

Within this project, it is crucial to calculate potential measures implemented to improve KPI scores into the business model of the respective entrepreneurs. Within the project, an extensive calculation model has been developed, allowing potential measures to be assessed in the financial balance. This makes it possible to assign a monetary value to each KPI.

All consequences for the cropping plan (cultivation costs and revenues) and the dairy farming enterprise (expenses and milk revenues) are comprehensively accounted for. This document has been delivered within Agrifirm and FrieslandCampina.

Results Case 1:

Opportunities and description of the concept:

For case 1, 2 scenarios have been developed (short/medium term and long term) that aim to transition towards a regenerative farming operation. The respective farmers see potential in these scenarios and have the intention and desire to implement the short/medium-term scenario (if possible, starting in 2024).

Opportunities and description of the concept in the short/medium term:

Implementing full crop rotation, this essentially means that a large mixed rotation of forage and arable crops is established across both farms. This leads to improvement of soil health, organic matter, carbon footprint, ammonia emissions, nitrogen and phosphate surplus. The farms can be self-sufficient in feed and manure and can implement a less intensive crop rotation plan. Moreover, it appears feasible to employ a regenerative cultivation method for seed potatoes while maintaining production.

The description of the headlines of the concept are in table 1 and the positive results of the KPI's are shown in table 2 and 3.

Working with the KPI's of soil health (total microbial mass, organic matter, mineral plant availability, worm population, aggregate Stability, plant health & dissolved solids) on plot level provides insight into the initial condition of the fields. This gives the opportunity to take, pro-active, plot-specific measures and adjust the crop plan to match the capabilities of the fields.

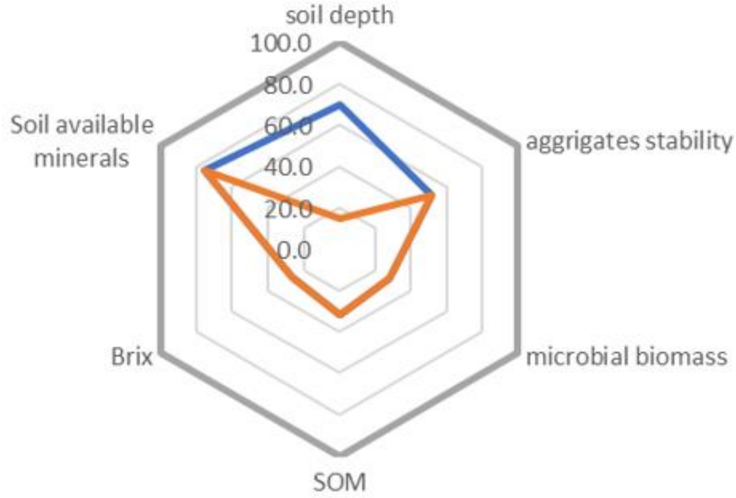


Figure 4: Example of the spiderweb of soil KPI's (plot level)

	Current - Conventional	0-5 years - transitioning to regenerative with the help of short chain
Agricultural Crop Plan	1-3 Seed Potatoes	1-4 Seed Potatoes
Seed potatoes	Conventional cultivation plan	Option 1) Cover crop on flat land in winter, ridge formation in spring, Potato + evergreen companion.
		Option 2) Fall - Bed preparation & Sow cover crop Winter - Cover crop survival/growth; potential grazing of cover crop Spring - Milling, ridge formation + potato and companion crop; Hilling + companion crop; after hilling Cover crop on row lanes Summer - Harvest potatoes from the spent companion crop & low-growing cover crop
Feeding plan	Regular	Maximize grass (mixtures)
		Supplement ration with local circular products.
		Purchase externally only what is necessary for production.
		Add Bovaer to the ration
Regular Crop Rotation plan	1.Potatoes	1.Potatoes
	2. Corn/grass/cereals/beans	2.Corn/fodder beet/grass/cereals/legumes
	3.Grass	3. Grass (30 hectares of diverse herbs, of which 25 hectares are permanent grassland)
		4. Grass (grass clover)
Animal Health	High content of cereals/beans, etc.	Minimal content of cereals/beans, etc.
Livestock	100 milking cows on 123.3 ha	100 milking cows on 123.3 ha
	Holstein: 10,359 kg of milk	Holstein: 10,359 kg of milk
	35% retention of young stock	35% retention of young stock
Grazing	Grass	Grass-clover + various herbs
	Grass clover	Grazing of selected landscape elements / Prunings
	Herb rich grassland	Early and late grass mixtures
Fertilization	Slurry (solid and liquid fractions)	Addition of Vizura to manure
	Synthetic fertilizer	Application of liquid fraction on grassland, solid fraction on arable land
		Separate all imported manure as well
		Trace elements (rock dust/foliar fertilization)
		Phasing out synthetic fertilizer on grassland
Supplementary Feeding	Cereals – legumes – silage maize - etc.	Fodder beets – mixed silage – minimizing legumes and cereals
Plant protection products	Regular	Phasing out, guided by detailed regenerative cultivation plan - monitoring bij Environmental Impact Assessment
Landscape Elements	-	Implementing number of hedges and rows of shrubs

Tabel 1: Description (headlines) of the concept, short/medium term

Reduce and avoid farm level					
Impact areas		**KPI**	**Unit**	**Score Current Situation**	**Score scenario 0-5 year**
Climate	GHG emissions	CFP milk	eq CO_2 / kg milk (incl ha fodder crops)	922	**650**
		CFP arable	eq CO_2 / ha (only ha arable output crops)	3867	**3000**
Air	NH_3 emissions	Ammonia emissions livestock	kg NH / GVE	33,6	**30**
		Ammonia emissions arable	kg NH / ha output crops	31,9	**30**
Water	N water pollution	Nitrogen soil surplus	kg N/ha	50	**0**
	P_2O_5 (phosphate) water pollution	phosphate soil surplus	kg P_2O_5 / ha	0	**0**
Nature	Disturbance - Pesticide use	Milieumeetlat - Plant Protection products	Points/ha (once per 10 ha > 100 points)	0,1	**0**
	Disturbance - Land use	% of protein produced in farm	% of protein produced in farm	75	**80**
	Disturbance - Land use	ha area covered x number of months covered <->the total farm area	ha area covered x number of months covered <->the total farm area	87,5	**100**
Reduce and avoid plot level (example one of the plots)					
Soil	Soil compaction (bodemdiepte)	penetration resistance, closest to Aggregate Stability	CM - (penetrometer test)	75,4	**100+**

Tabel 2: Impact on KPI's - short/medium term

Improve and restore farm level					
Impact areas		**KPI**	**Unit**	**Score Current Situation**	**Score scenario 0-5 year**
Climate	Soil carbon stock and sequestration	C Sequestration rate (organische stofbalans)	(Kg C / ha / yr) Total hectares output crops & foddercrops	4224/Ha	**5000**
	Using renewable energy	% Renewable energy	% Renewable energy	1/%	**86%**
Soil	Soil Health Farm Level	Permanent grassland	% Of farm under permanent grassland	16	**51**
		Crop diversity	number of different crops per calendar year corrected for farm scale	1,42	**1,53**
		Tillage index (% area)	tillage index (% area)	67,6%	**100**
		% Rest crops	% of farm/year	52,8%	**56%**
Nature	Habitat	Area of herb rich grasslands	% of farm under herb rich grassland	37,5% of the grass 13,4% of the total area	**61% of the grass, 24% of the total area**
		Area of landscape elements	% of farm under landscape elements	0%	1%
Improve and restore plot level (example of one of the plots)					
Soil	Soil Health Plot Level	Total microbial mass	amount	427	no target value yet
		% Organic matter	%	4,4	**+ 0,1-0,3% / yr.**
		Mineral Plant availability	% of max target range	41%	**75%**
		Worm population	Amount per scoop	1,2	**15**
		Aggregate stability	score out of 10	5,1	**8**
Improve and restore crop level (example of one of the crops)					
soil	Plant Health Plot Level	Dissolved solids	BRIX	0,9	**4,7**

Tabel 3: Impact on the KPI's - short/medium term

Opportunities and description of the long-term concept:
This scenario is an evolution of a joint cropping and soil plan, a fully regenerative cultivation of seed potatoes, further extensification of the crop plan, a different breed of dairy cattle, and the complete phase-out of synthetic fertilizers and pesticides.

Tabel 4 shows a description (main outline) of a potential long-term scenario where the regenerative system is the ultimate goal and in table 5, 6 and 7 the results of the KPI's.

The KPI scores in this practical case study demonstrate that implementing the long-term scenario, based on the calculation models, shows significant improvements in various aspects, including carbon footprint (46% to 60% reduction), emissions (22% to 26% reduction), and N leaching (100% reduction). The objective of 3XR is to achieve a collaboration resulting in climate-neutral food production. The outcomes of this case study demonstrate that with the measures implemented so far, a climate-neutral outcome has not yet been achieved. This appears to be a challenging goal that requires additional measures.

In this scenario (in contrast to the mid-term scenario), the balance (calculation based on current market prices) turns negative. This is primarily driven by the use of a different breed for dairy cow (lower proportion of self-grown concentrated feed) with lower production, a more extensive crop plan resulting in lower potato seed output (1 to 5), replacing use of crop protection by bio stimulants and other components for a healthier crop, increasing grazing and the absence of artificial fertilizers.
The positive environmental aspects cannot yet be adequately valorized in the market.

	Current - Conventional	**Long term: Ground-based and partnership arable farmer. Regenerative system**
Crop Plan	1-3 Seed Potatoes	1-5 Seed Potatoes
Seed potatoes	Conventional cultivation plan	Option 1) Fall - Bed preparation & sowing cover crop + planting potatoes under cover crop Winter - Cover crop survival/growth; potential grazing of cover crop Spring - Mowing/rolling cover crop Summer - Harvesting potatoes from the ridge & straw layer
		Option 2) Fall - Grass mixture Winter - Grass mixture Spring - Maximum grazing; graze => die off; lay potato + cover crop on the ground; straw over it Summer - Harvest potatoes from straw layer
Feeding plan	Regular	100% self-sufficient
Regular Crop Rotation plan	1.Potatoes	1.Potatoes
	2. corn/grass/ cereals/beans	2.Corn/fodder beet/grass/cereals/legumes .
	3.Grass	3.Grass
		4.Grass
		5.Grass
Animal Health	High content of cereals/beans, etc.	100% grass, hay, silage, fodder beets, browse hedge
Livestock	100 milking cows on 123.3 ha	120 animals on 120 ha
	Holstein: 10,359 kg of milk	Blaarkop / Jersey: 8,000 kg of milk
	35% retention of young stock	Lower % young stock / Higher % lactating cows
Grazing	Grass	Highly diverse grazing land
	Grass clover	Grazing of hedges and trees
	Herb rich grassland	Early and late grass mixtures
Fertilization	Slurry (solid and liquid fractions)	Maximum separation of slurry (liquid and solid fractions)
	Synthetic fertilizer	Surface-applied enriched solid fraction with trace elements and microorganisms ~ 7 times per year
		No synthetic fertilizer
		(Composted) prunings from the browse hedge
Supplementary Feeding	Cereals – legumes – silage maize - etc.	Only fodder beets and mixed silage
Plant protec-tion products	Regular	Only virus & Phytophthora control if necessary
Landscape Elements	-	Grazing hedges and trees planted on all plots.

Tabel 4: Description of the long term scenario

Reduce and avoid Farm Level					
Impact areas		**KPI**	**Unit**	**Score Current Situation**	**Score scenario long term**
Climate	GHG emissions	CFP milk	eq CO_2 / kg milk (incl ha fodder crops)	922	**500**
		CFP arable	eq CO_2 / ha (only ha arable output crops)	3867	**1500**
Air	NH_3 emissions	Ammonia emissions livestock	kg NH / GVE	33,6	**25**
		Ammonia emissions arable	kg NH / ha output crops	31,9	**25**
Water	N water pollution	Nitrogen soil surplus	kg N/ha	50	**0**
	P_2O_5 (phosphate) water pollution	Phosphate soil surplus	kg P_2O_5 / ha	0	**0**
Nature	Disturbance - Pesticide use	Milieumeetlat - Plant Protection products	Points/ha (once per 10 ha > 100 points)	0,1	**0**
	Disturbance - Land use	% of protein produced in farm	% of protein produced in farm	75	**92**
	Disturbance - Land use	ha area covered x number of months covered <->the total farm area	ha area covered x number of months covered <->the total farm area	87,5	**100**
Reduce and avoid Plot Level (example one of the plots)					
Soil	Soil compaction (bodemdiepte)	penetration resistance	CM - (penetrometer test)	75,4	**100+**

Tabel 5: Impact on KPI's – Long term

Improve and restore Farm Level					
Impact areas		**KPI**	**Unit**	**Score Current Situation**	**Score scenario long term**
Climate	Soil carbon stock and sequestration	C Sequestration rate (organische stofbalans)	(Kg C / ha / yr.) Total hectares output crops & foddercrops	4224/Ha	**6000/Ha**
	Using renewable energy	% Renewable energy	% Renewable energy	1/%	**100%**
Soil	Soil Health Farm Level	Permanent grassland	% Of farm under permanent grassland	16 %	**68%**
		Crop diversity	number of different crops per calendar year corrected for farm scale	1,42	**1,57**
		Tillage index (% area)	tillage index (% area)	67,6%	**100**
		% Rest crops	% of farm/year	52,8%	**69%**
Nature	Habitat	Area of herb rich grasslands	% of farm under herb rich grassland	37,5% of the grass 13,4% of the total area	**68% of the Grass, 41%of the total area**
		Area of landscape elements	% of farm under landscape elements	0%	**1,5%**

Tabel 6: Impact on KPI's – Long term

Preconditional outcomes farm level					
Impact areas		**KPI**	**Unit**	**Score Current Situation**	**Score scenario long term**
Farmer's liveli-hood	Farmer income	Farmer revenue	Saldo; euro	Current	**64K negative**
Animal Health & Welfare	Animals have a life worth living	KalfOK-score	score 0-100 points	90	**90**
		KoeData-score	score 0-100 points	98	**98**
		Longevity	length of cow life; age at culling in years-months-days	5 year, 9 mth, 9 dg	**6,5**
		Use of antibiotics	Dierdagdosering, DDD; daily doses animal, DDDAF	2,27	**1,5**

Tabel 7: Impact on KPI's – long term

Results Case 2:

Opportunity and description of the concept short- midterm:

For case 2, the focus has been placed on the development of a short/medium-term scenario in which 4 partners (a dairy farmer and 3 arable farmers) take a significant and realistic step towards regenerative farming practices. Case 2 is more complex than case 1 because it involves multiple farmers, and the proposal has not yet been thoroughly discussed with all the entrepreneurs, partly due to high workload on the farms. The dairy farmer indicates that there are elements in the scenario that could align with their goals. However, this will need further elaboration.

Just like in case 1, there are also possibilities of implementing (a part of a) full crop rotation, a large mixed rotation of forage and arable crops established across both farms. This leads to improvement of soil health, organic matter, carbon footprint, ammonia emissions, nitrogen and phosphate surplus. The farms can be self-sufficient in feed and manure, can implement a less intensive crop rotation plan, can improve their grazing and pasture management. When implementing the mid-term scenario, farmers' income will remain unchanged compared to the current situation, based on the calculation models and current market prices.
See in table 8 the description of the headlines of the concept and in table 9 and 10 results of the KPI’s.

In case 2, there appear to be opportunities to implement a mono-digester. Initial calculations suggest that there may be potential, justifying the need to further detail and explore this possibility.
Experimenting with the soil kip’s learns that the most significant improvement for soil health can be achieved by gathering more plot-specific knowledge in the collaboration, and to act on that.

	Current - Conventional	0-5 years - transitioning to regenerative with the help of short chain
Feeding plan	Grass/corn/supplementary concentrate feed	Maximize grass mixtures
		Supplement ration with local circular products.
		Purchase externally only what is necessary for production
		Concentrate feed from local sources (brewer's grains, potato fibers, pressed pulp)
Regular Crop Rotation plan	Grass/corn – leasing sugar beets/potatoes	1.Potatoes
		2.Corn/fodder beet/grass/cereals/legumes
		3.Grass
		4.Grass
Livestock	240 animals on 115 ha	250 animals on 255 ha
	Holstein: 9,000 kg of milk	Holstein: 9,000 kg of milk
	High % young stock / Low % lactating cows	151 head of young stock for every 10 milking cows
Grazing	Grass	Grass-clover + various herbs
		Grazing of selected landscape elements / Prunings
		Early and late grass mixtures
Fertilization	Slurry	Addition of Vizura to manure
		Application of liquid fraction on grassland, solid fraction on arable land
		Trace elements (rock dust/foliar fertilization)
		Phasing out synthetic fertilizer
Plant protection products	Regular	Phasing out, guided by detailed regenerative cultivation plan - monitoring bij Environmental Impact Assessment
Landscape Elements	-	Implementing number of hedges and rows of shrubs

Tabel 8: Description (headlines) of the concept.

Reduce and avoid farm level					
Impact areas		**KPI**	**Unit**	**Score Current Situation**	**Score scenario 0-5 year**
Climate	GHG emissions	CFP milk	eq CO2 / kg milk (incl ha fodder crops)	1063	**838**
Air	NH3 emissions	Ammonia emissions livestock	kg NH / GVE	16,8	**15**
Water	N water pollution	Nitrogen soil surplus	kg N/ha	63	**0**
	P2O5 (phosphate) water pollution	Phosphate soil surplus	kg P2O5 / ha	-28	**0**
Nature	Disturbance - Land use	% of protein produced in farm	% of protein produced in farm	0,51	**0,6****
	Disturbance - Land use	ha area covered x number of months covered <->the total farm area	ha area covered x number of months covered <->the total farm area	0,9	**1**
Reduce and avoid plot level (example one of the plots)					
Soil	Soil compaction (bodemdiepte)	penetration resistance, closest to Aggregate Stability	CM - (penetrometer test)	46,2	**100+**

*** All the protein will be produced by local farmers*

Tabel 9: The impact of implementing this scenario on several key KPIs.

Improve and restore farm level					
Impact areas		**KPI**	**Unit**	**Score Current Situation**	**Score scenario 0-5 year**
Climate	Soil carbon stock and sequestration	C Sequestration rate (organische stofbalans)	(Kg C / ha / yr.) Total hectares output crops & foddercrops	9692	**12978**
	Using renewable energy	% Renewable energy	% Renewable energy	35%	**75%**
Soil	Soil Health Farm Level	Permanent grassland	% Of farm under permanent grassland	23% / 39%	**50%**
		Crop diversity	number of different crops per calendar year corrected for farm scale	1,14	**1,61**
		Tillage index (% area)	tillage index (% area)	59% NKG	**100%**
		% Rest crops	% of farm/year	62%	69%%
Nature	Habitat	Area of herb rich grasslands	% of farm under herb rich grassland	0	25% of the grass, 8% of the total area
		Area of landscape elements	% of farm under landscape elements	1 single%	2%
**Improve and restore Plot Level (example of one of the plots) ** **					
Soil	Soil Health Plot Level	Total microbial mass	quantity	0,26	**no target value yet**
		% Organic matter	%	7,04	**no target value yet**
		Mineral Plant availability	% of max target range	75%	**75%**
		Worm population	Number per scoop		**15**
		Aggregate stability	score out of 10	10 (NB: needs to be checked	
**Improve and restore crop level (example of one of the crops) ** **					
Soil	Plant Health Plot Level	Dissolved solids	BRIX	2,5 - 4,0	**4,7**

Tabel 10: The impact of implementing this scenario on several key KPIs.

* The soil KPIs of multiple fields have been analyzed. Naturally, the outcomes vary greatly per field depending on soil type and history. Furthermore, it is important to monitor these KPIs over an extended period to draw conclusions. The above is just a small example of one specific field where the insights were already useful for implementing improvement measures.

Preconditional outcomes farm level					
Impact areas		**KPI**	**Unit**	**Score Current Situation**	**Score scenario 0-5 year**
Farmer's liveli-hood	Farmer income	Farmer revenue	Saldo; euro	Current Saldo	**Un-changed**
Animal Health & Welfare	Animals have a life worth living	KalfOK-score	score 0-100 points	80	**90**
		KoeData-score	score 0-100 points	97	**97**
		Longevity	length of cow life; age at culling in years-months-days	4,09	**5,5**
		Use of antibiotics	Dierdagdosering, DDD; daily doses animal, DDDAF	2,09	**2,0**

Tabel 11: The impact of implementing this scenario on farmer income and animal health and welfare

Conclusion and recommendations

There appear to be opportunities for livestock farmers and arable farmers to collectively transition towards a more regenerative approach to agriculture in terms of reducing the carbon footprint of milk and crop output, reducing nitrogen and phosphorus leaching into surface water, reducing pesticide pollution, and improving soil health. Calculations show that this could potentially be achieved while maintaining income for both dairy farmers and arable farmers. However, a crucial precondition for this change is that the financial risks associated with changes in crop and feed types, as well as potential feed quality issues, must be minimized through financial resources and guidance to make the transition attractive to farmers.

The key solutions identified in this project include the implementation of a joint cropping and soil plan, with a primary focus on soil health, which can achieve self-sufficiency in animal feed and manure, as well as improved crop management. This involves a shift from the arable farmer cultivating three crops, including potatoes, to cultivating four crops, including potatoes and animal feed. Through adjustments in crop management and the reduced need for non-local purchases of animal feed, this will result in a lower carbon footprint for feed and, consequently, for milk, lower carbon footprint for crop output, reduced nitrogen and phosphorus leaching, decreased reliance on pesticides, and improved soil health.
As observed from the short/mid term scenario of case 1, the measures are expected to achieve a reduction in the carbon footprint (indicatively 20% to 30%), reduction of ammonia emissions (6%-10%) and a reduction of nitrogen and phosphate surplus (100%) in 5 years. However, to become completely climate-neutral, it is evident that additional measures are still required.

Another identified solution direction, synergy in fertilization (reduction of synthetic fertilizer, manure digestion, application of manure digestate), is interesting enough to be further elaborated upon. The details in phase 1 were insufficient to make a definitive statement.

This exploration took place with two types of arable farmer/dairy farmer combinations, differing in soil type (clay and peat) and farming practices. Potential was found for both. Further implementation of the findings in practical cases can confirm and strengthen this potential.
To bring both practical cases to implementation, the following are needed:

- Detailed implementation plan in co-creation with the involved farmers, including:
  - Integrated soil- and rotation plan, feed strategy and regenerative cultivation method.
  - Required budget for guiding and advising the farmers and perform soil analysis.
  - Required budget for knowledge exchange.
  - Update the revenue models, including those for all involved arable farmers.
  - Accurate calculation of transition costs and financial risks.
- Covering financial risks.
- Elaboration on the feasibility of a mono-digester.
- Coordinate and secure commitment from all relevant partners: farmers, Provincie Groningen, ISPT, FrieslandCampina, and Agrifirm.
- Draft contracts/agreements.

Discussion

Income
The objective also includes improving the income of farmers, which currently appears to be unattainable in the most intensive collaboration between the arable farmer and dairy farmer. The improved performance in areas such as emissions and biodiversity does not translate into better market prices. At present, it is only partially possible to convert the reduction in the carbon footprint into a higher milk price. This market situation complicates the transition.

Transition phase
Bringing soil health to its maximum level, based on regenerative principles, typically takes 5 to 10 years. During this period of significant changes in feed and crop management, it is essential to invest in knowledge (including external advice) and numerous soil analyses. Making fields more disease-resistant on the one hand and reducing the use of pesticides on the other hand is a delicate balancing act. Farmers perceive financial risks in this process, with income expected to remain stable. Finding a solution for potential transition costs and risks is crucial.

Soil KPI's and dashboard
In a regenerative system, soil health is crucial, and so is monitoring the key soil KPIs. These soil KPIs need to be examined at field level and typically require analysis over an extended period to observe trends. This complexity makes it more challenging to easily scale up a dashboard, including soil KPIs.

Climate Neutral
The concept of collaboration through a shared soil and cultivation plan, as well as regenerative crop cultivation, will need further development to achieve fully climate-neutral production.

Impact

Bijdrage aan KPI's van FASCINATING

KPI's van het Fascinating-programma	***streefwaarde in 2030 op programmaniveau***	*Bijdrage project - beschrijving*	*Bijdrage project - cijfers*
Economie			
Meeropbrengst in de keten door teelt van nutritioneel hoogwaardige gewassen	10-25%	NVT	
Toename Bruto Toegevoegde Waarde in de regio door verwaarding hoogwaardige producten	€ 200.000.000	NVT	
New Business voor de regio	€ 50.000.000	NVT	
Private investeringen in nieuwe economische activiteiten (unit operations, fabrieken, logistieke ketens)	€ 150.000.000	NVT	
Investeringen in R&D	€ 40.000.000	NVT	
Werken en leren			

Additionele banen die samenhangen met precisie-landbouw, digitalisering van landbouw tot hightech boerenbedrijf	100 fte	NVT	
Impuls op werkgelegenheid en welvaart in landbouwsector, verwerkende industrie, (bio)chemie, consumentenproducten	5000 personen	NVT	
Stageplekken en leerplaatsen	50	NVT	
Leefbaarheid			
Verbetering woon- en leefomgeving op het platteland		The reduction of pesticides contributes to an improvement of the living environment	
Gezondere leefomgeving (bodem-, water- en luchtkwaliteit)		Reduction of emissions will improve living environment	
Duurzaam en lokaal geproduceerde voiding			
Gezondere bevolking door betere voiding			
Bijdrage aan vitale economie met baankansen voor bevolking			
Natuur en klimaat			
Opwaardering van de regionale akkerbouw en veehouderij passend bij het klimaat en cultuurlandschap	50% areaal		
Bijdrage aan de ontwikkeling van een circulaire landbouw	25%		
Uitbreiding van het areaal met verbeterde biodiversiteit in 2030	25%		
Reductie broeikasgasemissie in de keten	50% areaal	Two cases shows reduction of carbon footprint (20% - 30%) in 5 years.	
Reductie stikstofemissie		Two cases shows reduction of ammonia emmissions (6%-10%) and a	

		nitrogen and pfosphate surplus (100%) in 0 in 5 years.	
Uitbreiding van het areaal met verbeterde bodemkwaliteit in 2030		Potentially 100% of the total area	

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