Towards Regenerative Agriculture at scale

Introductory presentation, June 2021

TOPSECTOR WATER & MARITIEM

Topsector Agri& Food

TOPSECTOR HORTICULTURE & STARTING MATERIALS

Rijksoverheid

Contents

The leading paradigm in agriculture since world war II: maximize efficiency

‘Mono’ populations in optimized environments

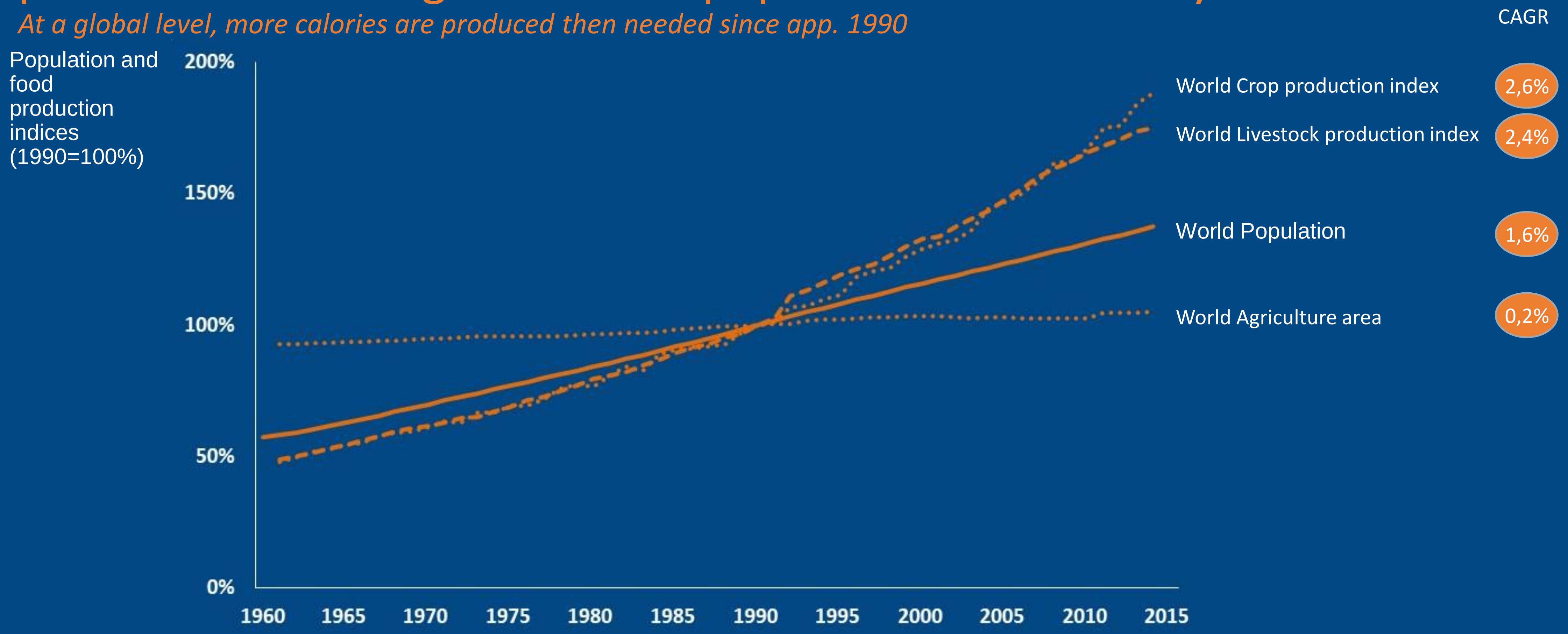

Cheap and predictable food


Simple ‘ruling’ technology
- high inputs – high losses per ha (though low per kg)


Source: Synergia consortium, Peter Groot Koerkamp

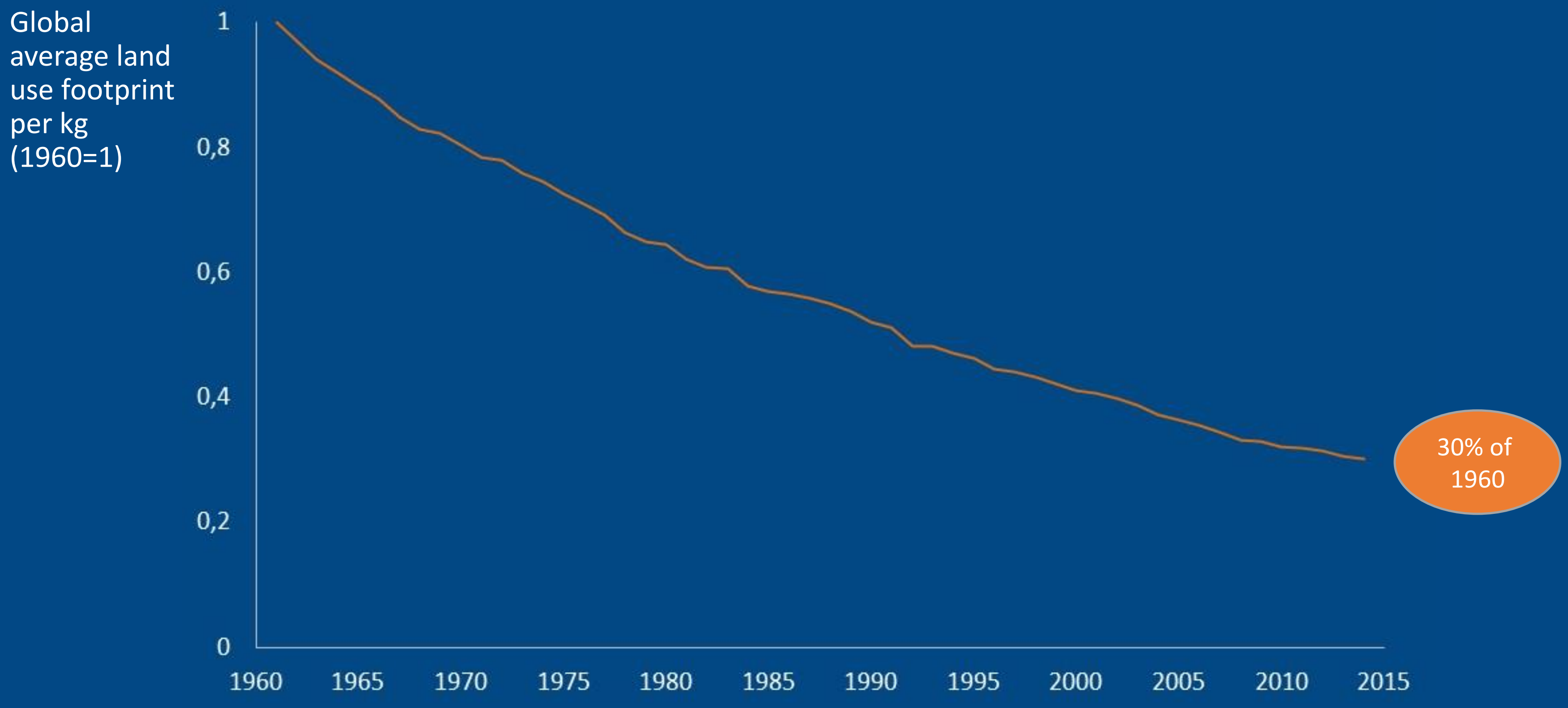
Maximize efficiency has been a very successful paradigm: Global agriculture production has outgrown world population for over 60 years……..

At a global level, more calories are produced then needed since app. 1990



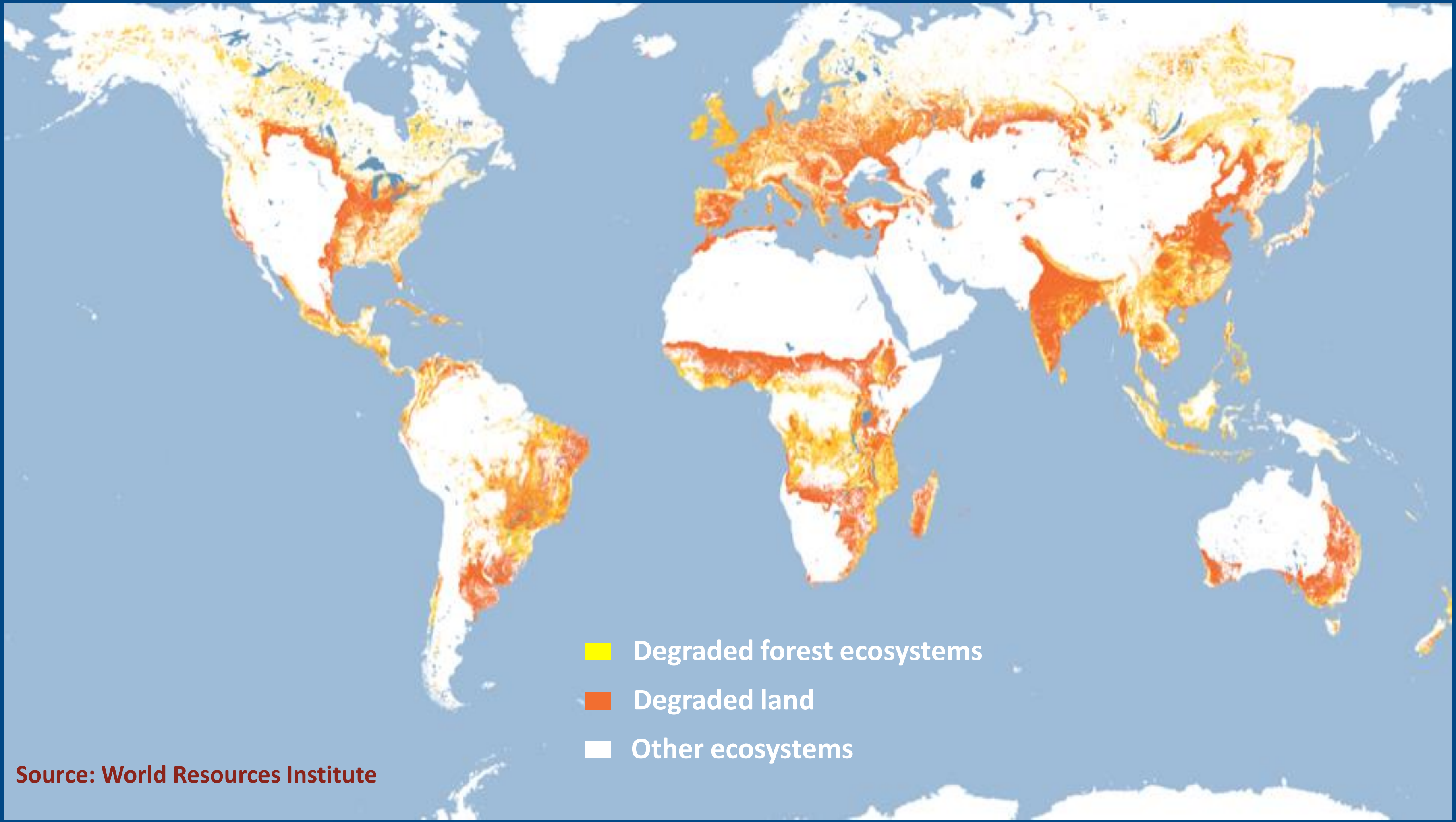
Source: World development indicators: http://databank.worldbank.org/data/source/world-development-indicators#, FAO: https://ourworldindata.org/hunger-and-undernourishment, Time 2017: http://time.com/4813075/obesity-overweight-weight-loss/

…… and land use footprint per kg has been reduced dramatically….



Source: World development indicators: http://databank.worldbank.org/data/source/world-development-indicators#

…but land and ecosystem degradation is a global challenge…



…. and (soil) biodiversity is threatened globally

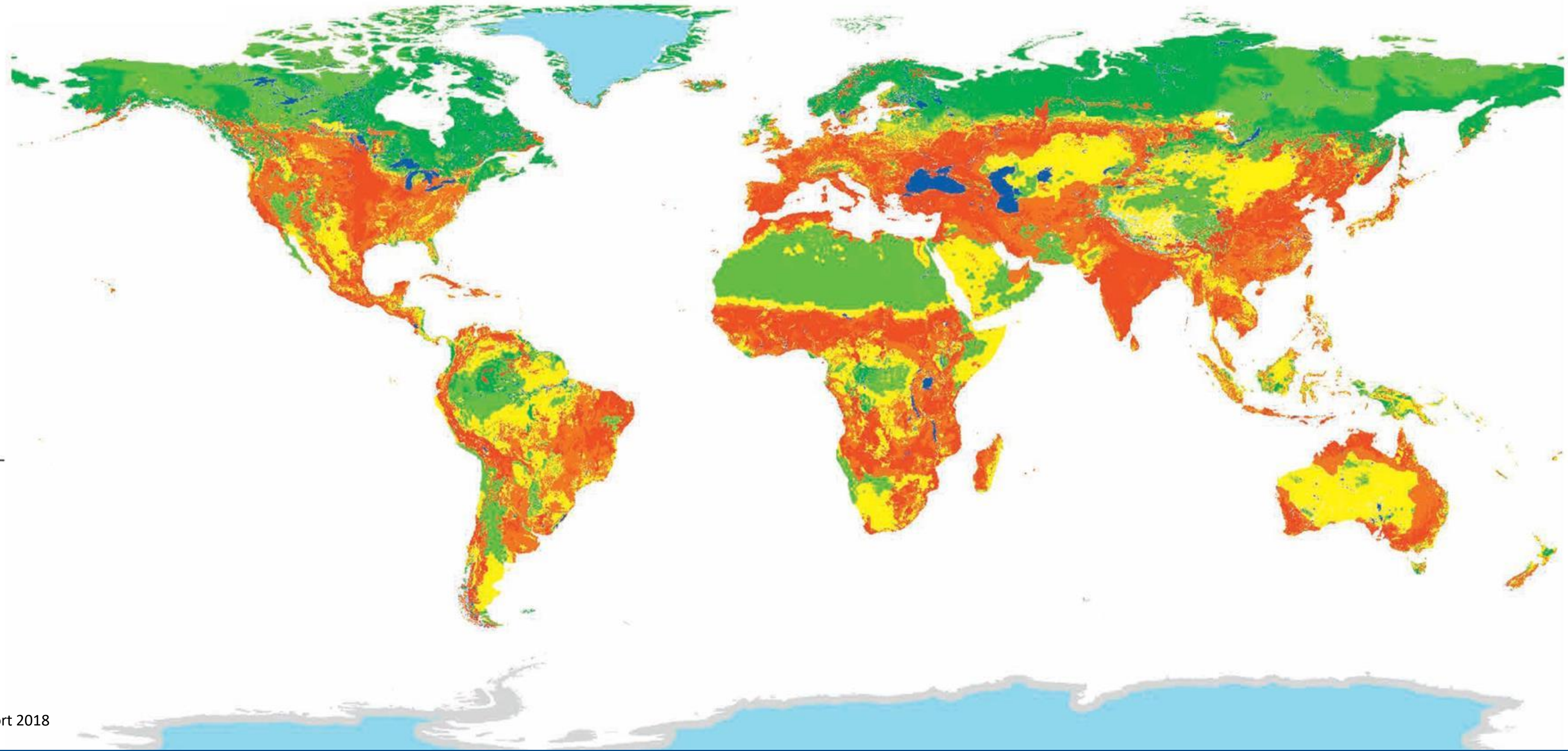


Figure 9: Global map showing the distribution of potential threats to soil biodiversity
All datasets were harmonized on a 0-1 scale and summed, with total scores categorized into five risk classes (from very low to very high)[39].

Key

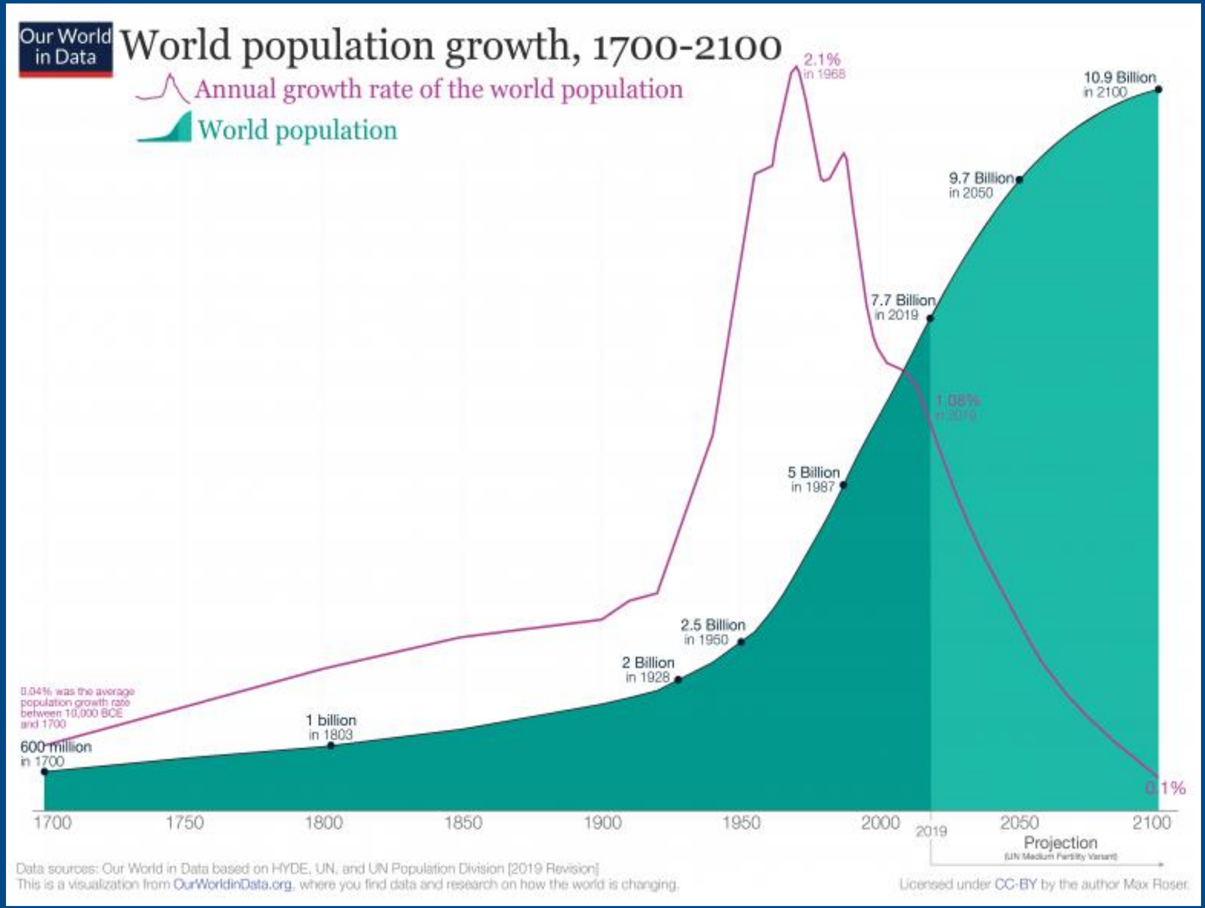
- Very low
- Low
- Moderate
- High
- Very high
- Not available
- Water
- Ice

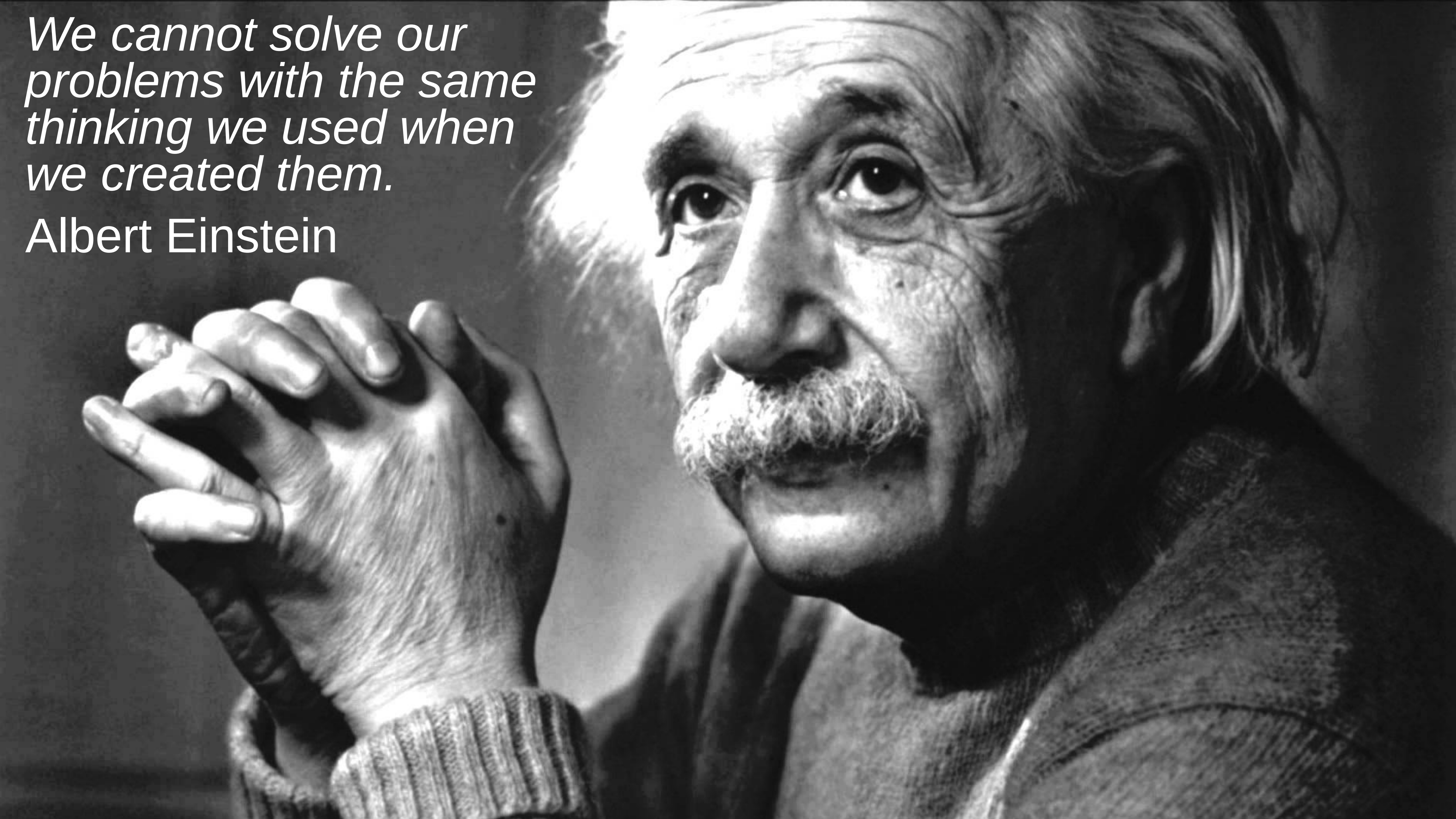
Source: WWF Living Planet report 2018

Global need to bend the curves on six earth system processes (EAT-Lancet, 2019) and produce sufficient food & biomass for growing world population

Earth system process	Control variable	Boundary (Uncertainty range)
Climate change	GHG emissions	5 Gt CO_2-eq yr^{-1} (4.7 – 5.4 Gt CO2-eq yr^{-1})
Land-system change	Cropland use	13 M km^2 (11–15 M km^2)
Freshwater use	Water use	2,500 km^3 yr^{-1} (1000–4000 km^3 yr^{-1})
Nitrogen cycling	N application	90 Tg N yr^{-1} (65–90 Tg N yr^{-1}) * (90–130 Tg N yr^{-1})**
Phosphorus cycling	P application	8 Tg P yr^{-1} (6–12 Tg P yr^{-1}) * (8–16 Tg P yr^{-1})**
Biodiversity loss	Extinction rate	10 E/MSY (1–80 E/MSY)

*Lower boundary range if improved production practices and redistribution are not adopted.
**Upper boundary range if improved production practices and redistribution are adopted and 50% of applied phosphorus is recycled.

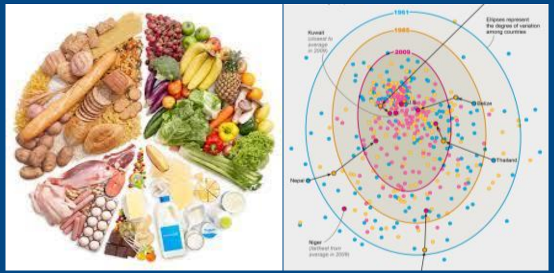



We cannot solve our problems with the same thinking we used when we created them.
Albert Einstein

Need for a new paradigm: Regenerative, circular, ecology-based agriculture

Diverse production with complex interactions

Changing market
dynamics and preferences



Intelligent small scale
‘supporting’ technology

Source: Synergia consortium, Peter Groot Koerkamp

Need new approaches to get to a regenerative and circular system at scale

	Today's dominant logic	Required for systemic change
Ambition	Volume growth, maximum efficiency; Less negative impacts	Value growth, optimum efficiency; Net positive impact
Scope	Supply chains, company by company, commodity by commodity	Integrated systems: fields, farms, local landscapes, value chains
Breadth of solutions	Dogmatic: prescribe 'one size fits all' agricultural practices	Drive to target outcomes with diversity of agricultural practices

Contents

Regenerative Farming Program - Introduction

Goal: Develop transition scenarios towards a regenerative agriculture system at scale, with positive impact on climate, nutrient cycles, soils, freshwater and biodiversity

Five program deliverables:

1. Integrated outline of a regenerative agriculture system at scale, for use case area the Netherlands
2. Assessment of expected impact of running initiatives and existing best practices towards these targets for 2050
3. Co-creating next practices of regenerative farming
4. 'Proof of principle' of regenerative agriculture for use case the Netherlands (at scale and with sound business models): several quantified scenario's in compliance with the outline for 2050
5. Science based and quantified transition scenarios from the existing agriculture system towards these 2050 scenario's

Consortium partners:

Universiteit Utrecht

TiFN FOOD & NUTRITION

FrieslandCampina nourishing by nature

Cosun

Rabobank

Topsector Agri& Food

Het Groene Brein

Universiteit van Amsterdam

wij•land

bo brancheorganisatie akkerbouw

Guiding principles for the approach

Multidisciplinary team, geared towards system transition and transdisciplinary research:

- Agro-ecology, innovation science, social sciences, agro-technology, public administration

Co-creation process

- Scientists, groups of dairy farmers and arable farmers, private sector

Strong involvement of leading players in Agriculture and Food System

- Start with Dutch dairy and arable farming: FrieslandCampina, Cosun and BO Akkerbouw
- Aim to extend to other sectors and other parts of the value chain
- Aim to extend to more countries

Program team to date

2 PhD candidates:

- Niko Wojtynia (Copernicus Institute)
- Loekie Schreefel (Wageningen University)

Supervisors and promotors:

- Peter Groot Koerkamp (WUR Farm Technology)
- Rogier Schulte (WUR Farming systems ecology)
- Imke de Boer (WUR Animal production systems)
- Hannah van Zanten (WUR Farming systems ecology)
- Marjolein Derks (WUR Farmi Technology)
- Annemiek Pas-Schrijver (WUR Farm Technology)
- Jerry van Dijk (UU Copernicus institute for sustainable development)
- Marko Hekkert (UU Innovation studies + head of Copernicus institute)
- John Grin (UvA Policy science)

TIFN Team:

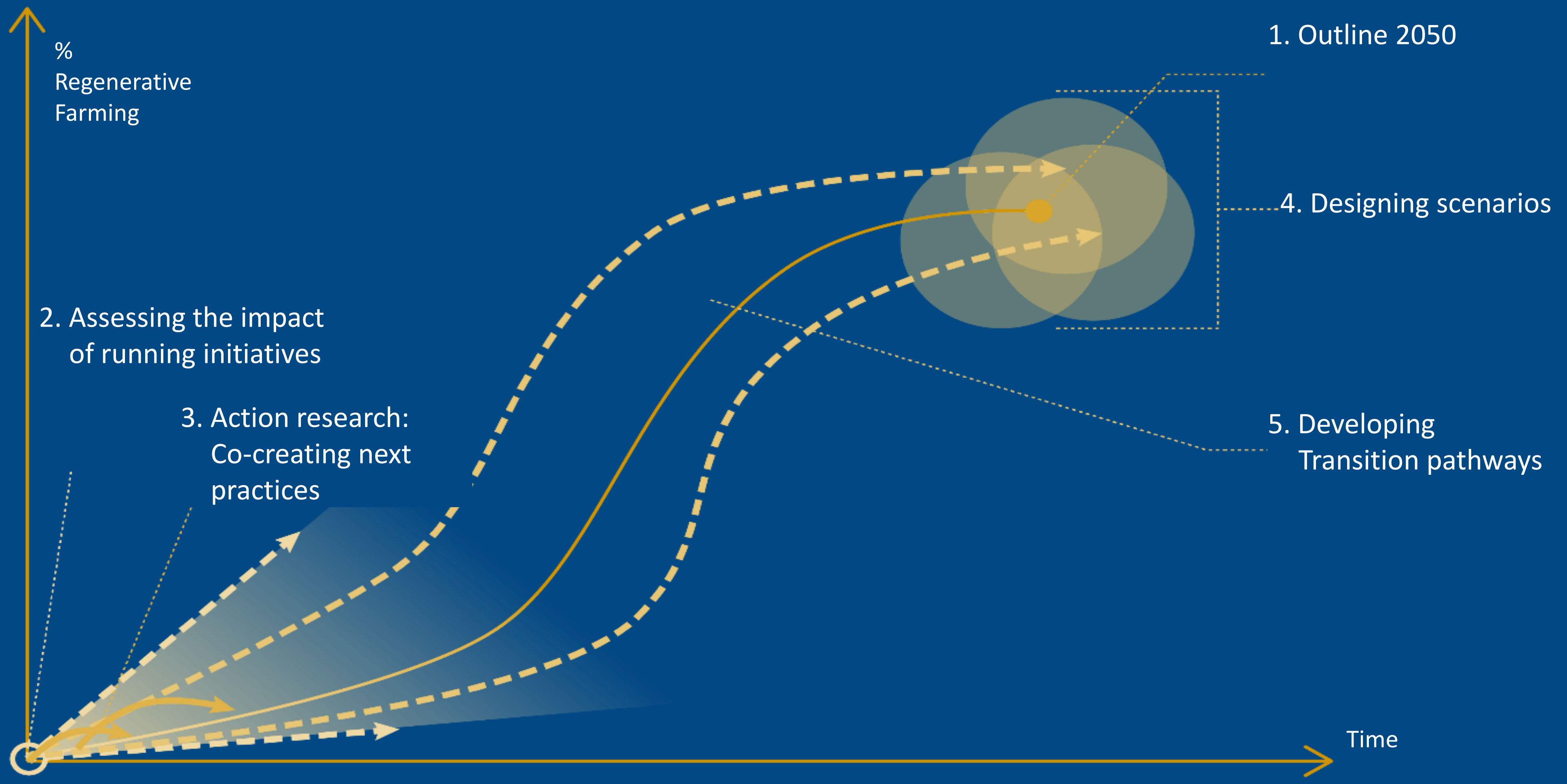
- Aafke van den Boom (Theme coordinator)
- Wouter-Jan Schouten (Theme director Sustainable Food Systems)

Community of practice of 20 farmers in the Netherlands that are pioneering regenerative practices

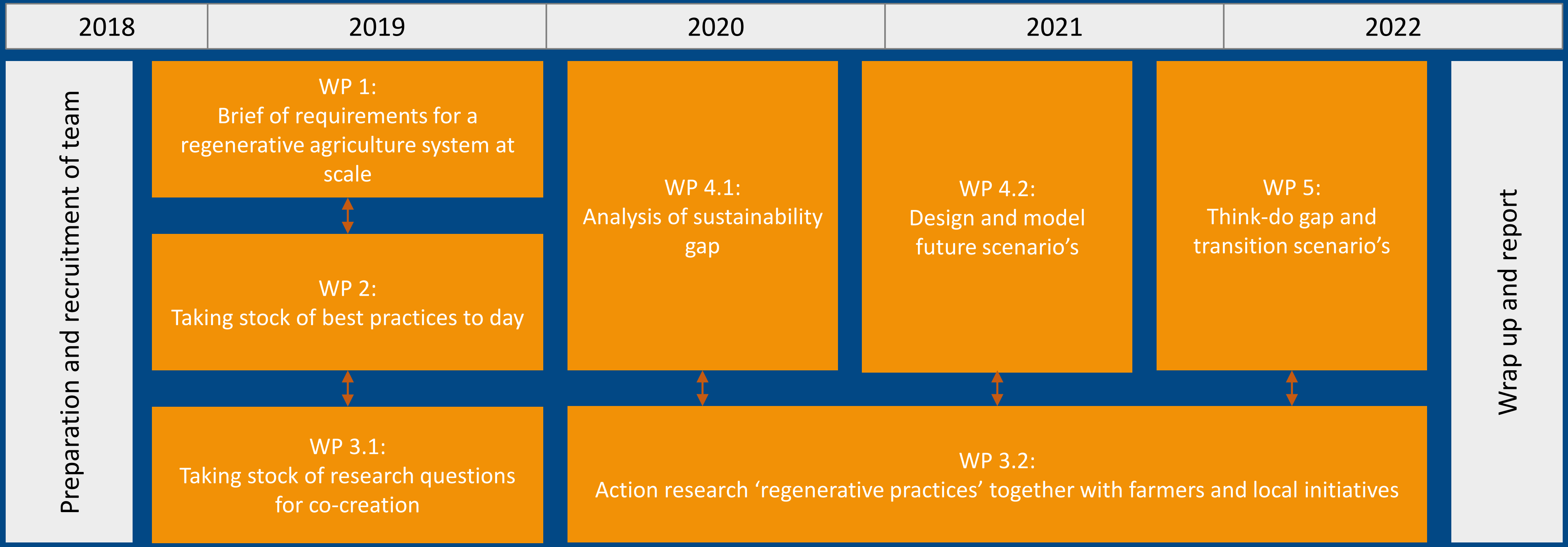
Support to community of practice:

- Bert Smit and Alfons Beldman (Wageningen Economic Research)
- Annemiek Pas Schrijver (WUR Farming systems ecology)
- Tatiana Moreira (WUR Farming systems design)
- Antoine Heideveld and Marjolijn de Boer (Groene Brein)
- Danielle De Nie and Matthijs Boeschoten (Wij.Land)
- Private sector partners (FrieslandCampina,
  BO Akkerbouw, Cosun, Rabo, other partners tbd)
- Expert panel with senior researchers from Wageningen Research, Louis Bolk Institute, and Delphi)
- On average 4-6 MsC students from WUR and UU

Five work packages



Project timeline



Papers Schreefel: (as planned to date)	1. Define regenerative farming	2. Explore the potential of cases towards reg. farming	3. Evaluate the potential of scaling up	4. Design transition scenario's
Papers Wojtynia: (as planned to date)	1. Analysis of policy visions	2. System barriers. What is holding back regenerative farming	3. Scenario's: what could future agri-food systems look like	4.Transition: how can scenario's in paper 3 be realized

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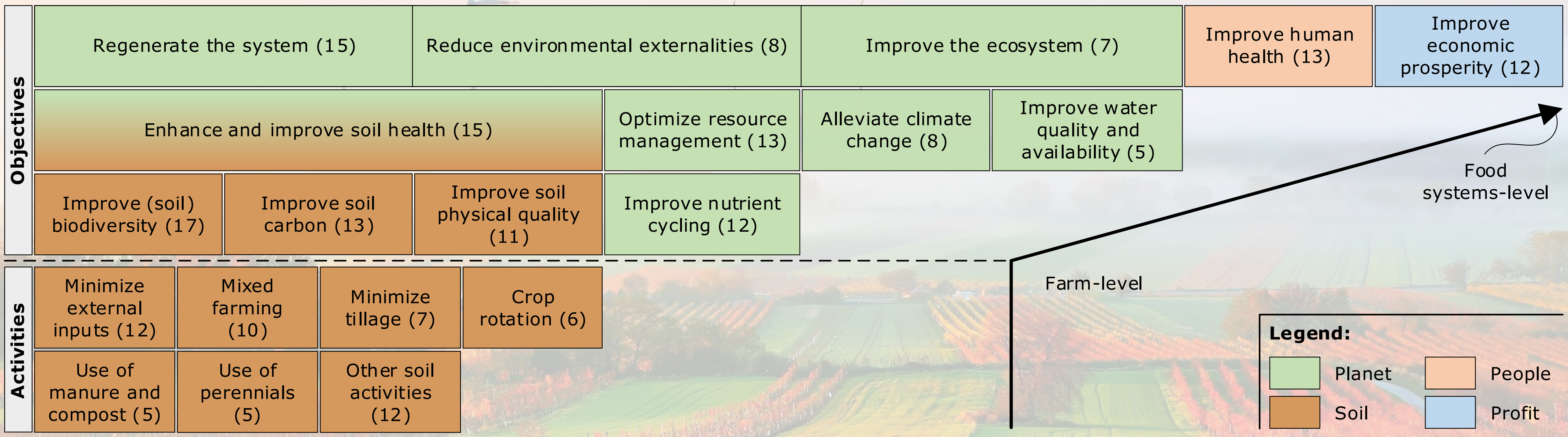
Regenerative agriculture – Proposed definition based on literature review



We propose to define regenerative agriculture as:
an approach to farming that uses soil conservation as the entry point to regenerate and contribute to multiple ecosystem services, with the objective that this will enhance not only the environmental, but also the social and economic dimensions of sustainable food production (Schreefel et al., 2020)

Proposed objectives of a regenerative agriculture system at scale

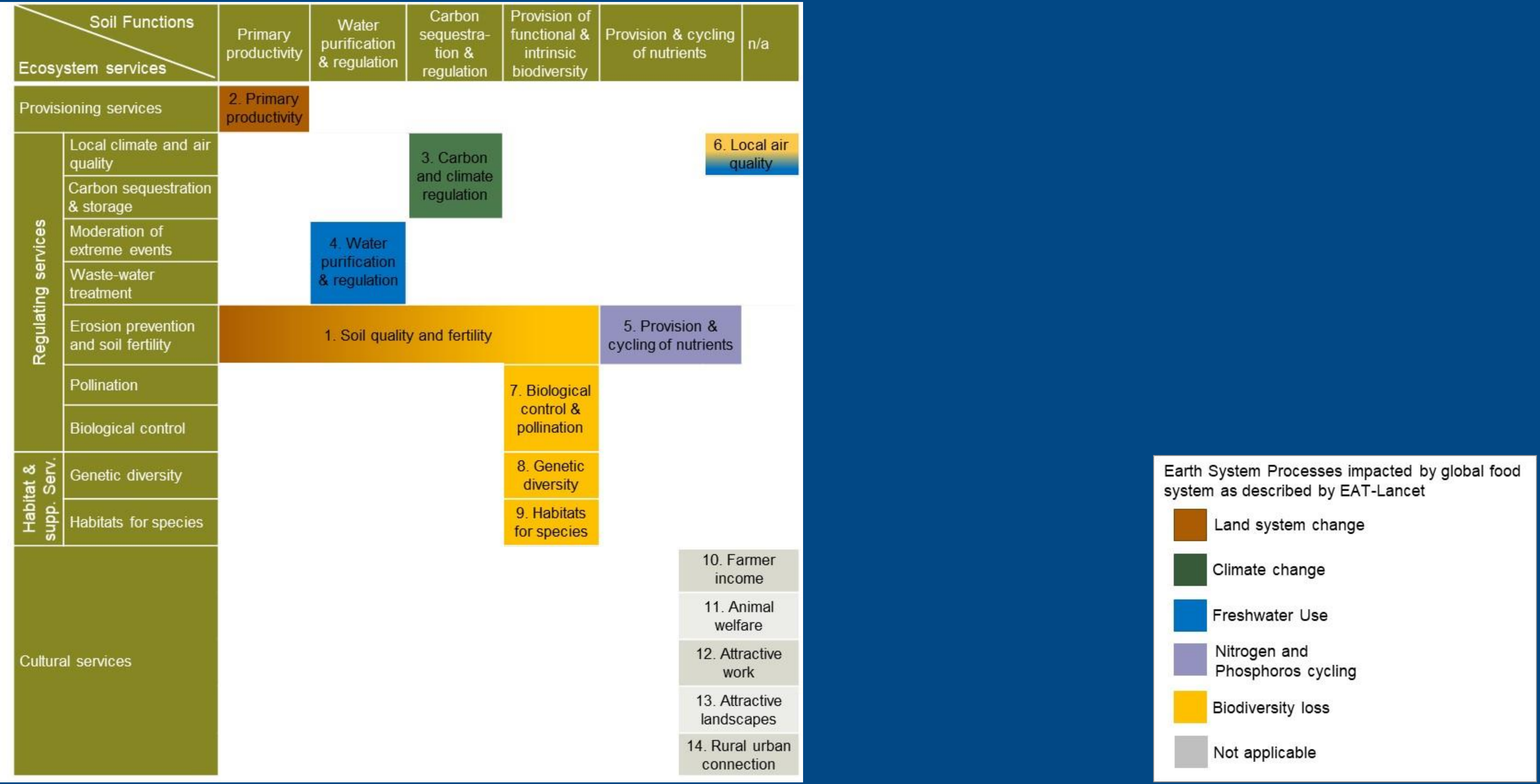
We propose the following vision for a regenerative agriculture system at landscape or higher levels:

A regenerative agriculture system enables production of food & biomass and enables ecosystems to maintain a healthy state and evolve, while contributing to biological diversity, integrity of the biosphere, human well-being and economic prosperity of society.

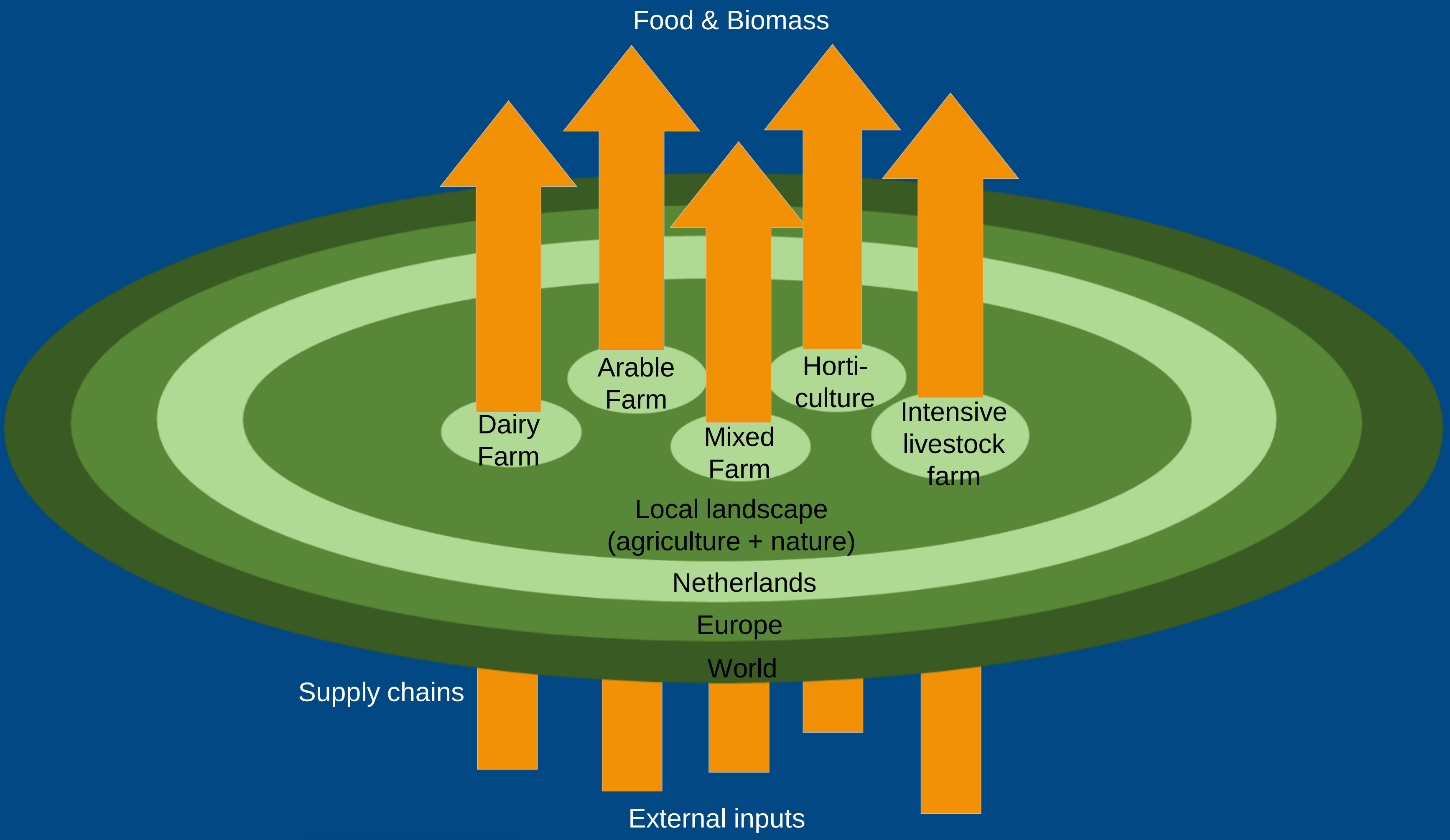
Need to bend the curves; required outcomes:

- Climate: Carbon capture > GHG emissions
- Land system change: Improve soil quality, enable nature restoration
- Freshwater use: Improve water quality and regulation
- Phosphorous and Nitrogen: Close nutrient cycles
- Increase biodiversity
- And: produce sufficient Food & Nutrition

Required outcomes defined on 14 topics covering all soil functions and ecosystem services



Required outcomes defined at different system levels



Headlines ‘Brief of Requirements’ (Groot Koerkamp et al., 2021)

Ecosystem services/soil functions	Required outcomes at field and/or farm level	Required outcomes at local or higher level
1. Soil quality + fertility, 3. carbon & climate regulation	• A resilient soil food web with functional redundancy; high abundance and richness of soil micro-biome • Resilient soil physical quality; a.o. dry bulk density < 1.6 g/cm^{-3} of dry matter • Soil organic matter > 4%-8% (soil and farm type dependent)	• EU Agriculture and nature combined are a ‘net carbon sink’ by 2050 • In between step, deliver on commitments in climate agreement, i.e. reduce net GHG-emissions from Dutch Agri + landuse with > 6 MT by 2030
2. Primary productivity of food & nutrition, raw materials and medicinal resources	• Production of safe and high-quality food and biomass	• Average production/ha high enough to produce sufficiënt food and biomass on < 11-15 M km^2 cropland, globally • Circular system; input/output ratio of human digestible protein < 1
4. Water purification & regulation	• Water usage ≤ natural available • Water storage capacity > … (soil type dependent)	• Water quality good/very good according to water framework directive • Water surpluses are collected as buffer • No negative impacts on water in natural areas and for local communities
5. Provision & cycling of nutrients 6. Local air quality	• N and P accumulation in soils limited to levels that minimize risk of leaching and high emissions to the environment • All N, P and micro-nutrients inputs in system come from renewable sources (air, manure or recovered from sewage/environment)	
	• No accumulation of Persistent organic pollutants (POPs) in soils, water or air	• Particulate matter < WHO limits • N deposition in natural habitats < EU limits • NO and NO_2 emissions within EU directives
7. Biological control & pollination 8. Genetic diversity, 9. Habitats for species	• >10% of each square km landscape (public space + farmland combined) is semi natural habitat	
	• year-round diversity of habitat and resource provision for farmland species for all stages of the life cycle. (providing habitat for farmland species and enabling natural pest control) • Abundance and diversity of populations for natural pest control	• Migration of species between all nature areas enabled • Diversity of gene pool for locally well-adapted crops and farm animals • Abundance and diversity of farm-land species and pollinators
10. Farmer income, 11. Animal welfare, 12. Attractive work, 13. Attractive landscapes, 14. Connection rural/urban	• Farmer incomes ≥ living income • Farm animals have a life worth living • Farms provide attractive and meaningful work	• Agricultural ecosystems in combination with nature provide attractive landscapes • Good connection between rural and urban communities

Required outcomes at farm level – long term objectives for each farm

Ecosystem services/ soil functions	Required outcomes at field and/or farm level	Field	Farm
1. Soil quality + fertility, 3. carbon & climate regulation	• A resilient soil food web with functional redundancy; high abundance and richness of soil micro-biome • Resilient soil physical quality; a.o. dry bulk density < 1.6 g/cm^{-3} of dry matter • Soil organic matter > 4%-8% (soil and farm type dependent)		
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10. Farmer income, 11. animal welfare, 12. attractive work	• Farmer incomes ≥ living income • Farm animals have a life worth living • Farms provide attractive and meaningful work		

Required outcomes above farm level – long term objectives on which individual farms can compensate for each other and/or can be compensated by nature/public areas

Ecosystem services/ soil functions	Required outcomes at local or higher level	Local Land scape	NL	Europe/ global
1. Soil quality + fertility, 3. carbon & climate regulation	• Agriculture and nature combined are a 'net carbon sink' • In between step, deliver on commitments in climate agreement, i.e. reduce net GHG-emissions from Dutch Agri + landuse with > 6 MT by 2030			
2. Primary productivity of food & nutrition, raw materials and medicinal resources	• Average production/ha high enough to produce sufficiënt food and biomass on < 11-15 M KM^2 cropland, globally • Circular system; input output ratio of human digestible protein < 1			
4. Water purification & regulation	• Water quality good/very good according to water framework directive • Water surpluses are collected as buffer • No negative impacts on water in natural areas and for local communities			
5. Provision and cycling of Nutrients, 6. Local air quality	• Particulate matter < WHO limits • N deposition in natural habitats < EU limits • NO and NO_2 emissions within EU directives			
7. Biological control & pollination 8. Genetic diversity, 9. Habitats for species	• >10% of each square km landscape (public space + farmland combined) is semi natural habitat • Migration of species between all nature areas enabled • Abundance and diversity of farm-land species and pollinators • Diversity of gene pool for locally well-adapted crops and farm animals			
13. attractive landscapes, 14. connection rural/urban	• Agricultural ecosystems in combination with nature provide attractive landscapes • Good connection between rural and urban communities			

Need diversity of solutions – some examples

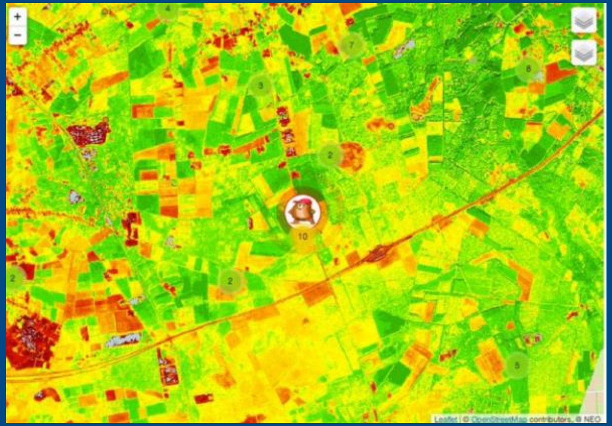
Intercropping

Circular, mixed farm

Agroforestry

Managed/strip grazing

Precision farming



Silvo pastures

Source: Inaugural address Rogier Schulte (2019)/ WUR-FSE Lighthouse farm network, Regenerative agriculture project

Diversity of solutions: Identified best agricultural practices

Ground-bound plant production practices:

- High diversity cropping patterns/ ‘stroken teelt’:
- No/minimize tillage
- Soil innoculation
- Use perennials
- Use of green manures, compost, crop residues
- High tech precision arable farming
- Tree intercropping (trees & arable farming)
- Permacultures/Agroforestry/Food forests
- Riparian buffers
- Conservation (wild harvesting)

Ground-bound animal production practices:

- Managed (strip) grazing on permanent herb rich grasslands
- Silvo pastures (trees & permanent grasslands)
- Minimized losses conventional animal husbandry

Ground-bound mixed plant/animal production practices:

- Integrated farm, in a new local ecosystem
- Local/Regional x-sector cooperation

Non ground-bound circular systems:

- Circular intensive animal husbandry
- High tech circular horticulture/ Urban vertical LED farming
- High tech circular mixed farming

Mosaic of solutions needs to add up to these system requirements

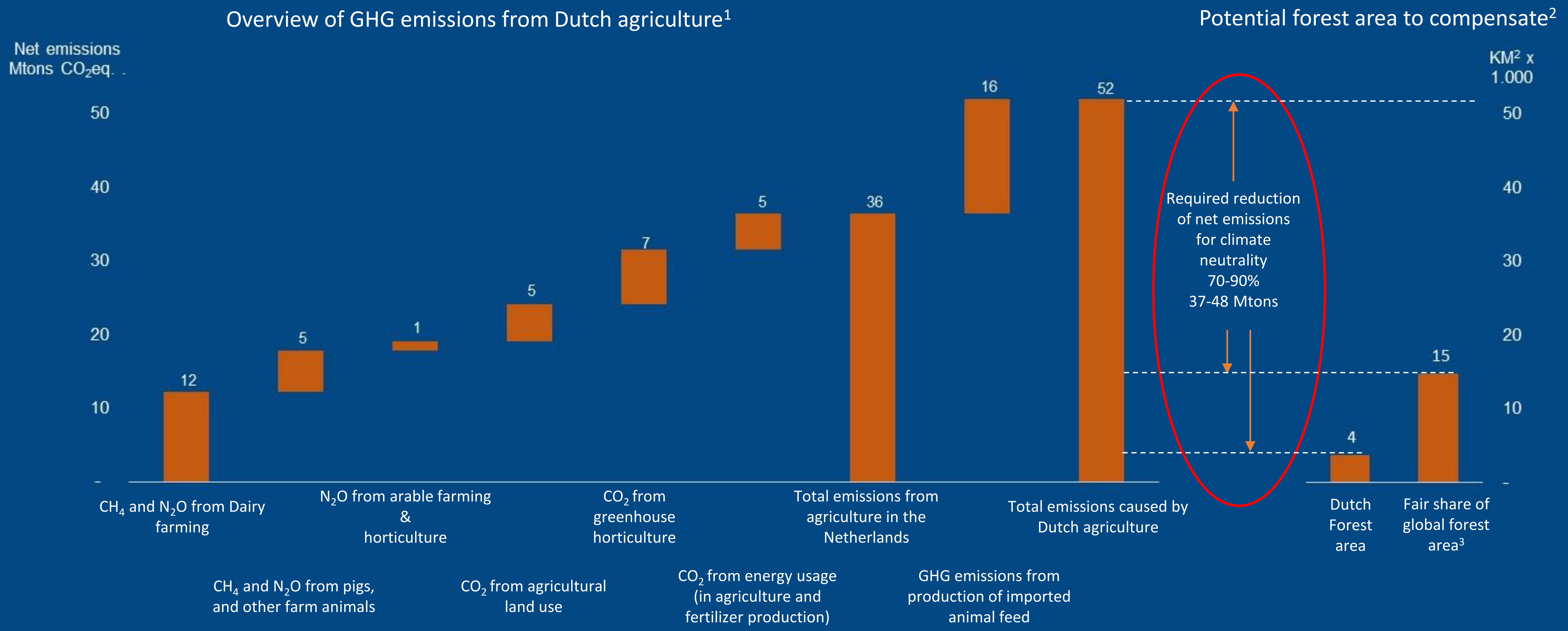
Widespread and sustained adoption of regenerative/ ecology-based plant production systems:
- Diverse cropping patterns in arable farming
- Land use for plant production a net carbon sink
- Biological/mechanical control of pests, weeds and diseases
- Climate neutral energy use
- All inputs from renewable sources
- Sufficient, year-round, habitat for biodiversity

Widespread and sustained adoption of regenerative/ ecology-based animal production systems that are symbiotic with plant production and nature:
- Biodiverse and resilient herds
- Fed with grass and/or side streams, sourced as locally as possible
- Amount and quality of manure optimized for needs of plant production
- Less GHG emissions than carbon capture through plant production and nature

Farmers and food chain companies use diversity of practices and technology that enables regenerative/ ecology-based production at scale, ensuring food security at affordable prices:
- sufficient labor productivity
- affordable technology
- optimal, minimized waste, food chain
- competitive farmer business models
- institutional environment that enables regenerative outcomes

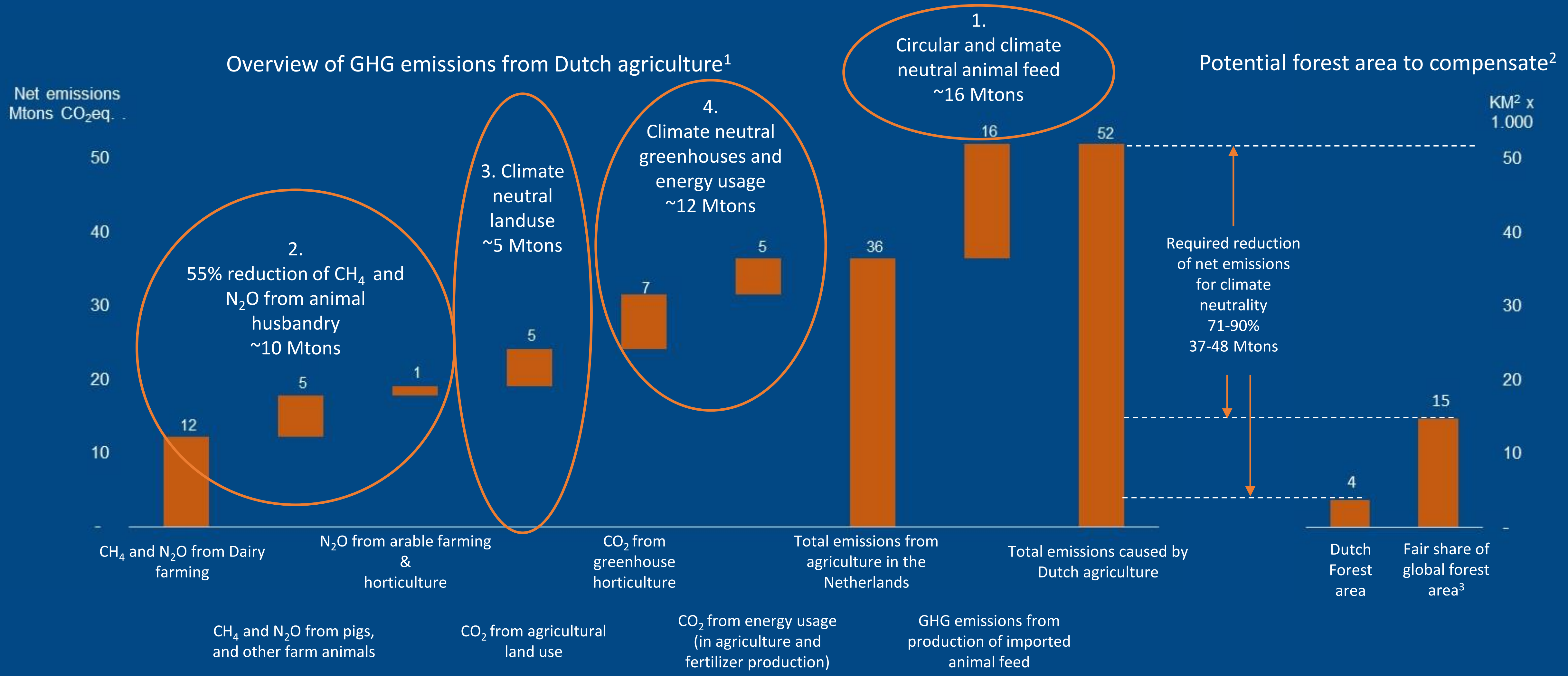
Source: Synergia impact plan (Work in progress by Peter Groot Koerkamp, Niels Anten, Wouter-Jan Schouten et al.)

Example: Required outcome of climate neutrality for Agriculture and Nature combined requires 70-90% reduction of net emissions caused by Dutch agriculture…



[1] Source: PBL, Balans van de Leefomgeving 2018; Vellinga, Reijs, Lesschen, van Kernebeek 2018
[2] Based on average of 10 tons CO_2 capture per hectare of forest per annum
[3] Based on global average ratio of 4 bln ha's forest divided by 4,8 bln ha's of agriculture area (crop land and permanent pastures); source: https://ourworldindata.org/forest-area

…… which implies four challenges to be tackled at national level……



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……. and four challenges at farm level

Material Incentives needed that enable farmers to meet these challenges

Animal husbandry

1. All animals fed with grass and/or climate neutral by-products
2. Emissions of CH_4 and N_2O of less than 4 tons CO_2 eq. per annum per hectare of land where manure of the farm is applied
3. Climate neutral land use:
   - On Peatland: CO_2 and N_2O emissions less then 7 tons CO_2 eq. per annum per hectare
   - On grasslands on mineral soils: sequester 1 ton CO_2 eq. per hectare per annum
4. Climate neutral energy usage

Arable farming

2. Apply fertilizer/manure that has caused less emissions than 4 tons CO_2 eq. per annum per hectare
3. Sequester 4‰ carbon per annum until soil organic matter >> 4%
4. Climate neutral energy usage

Agroforestry and permacultures

3. Sequester > 5 tons CO_2 per annum per hectare
4. Climate neutral energy usage

Greenhouse horticulture

1. Apply fertilizer/manure that has caused less emissions then 4 tons CO_2 eq. per annum per hectare
4. Climate neutral greenhouses

Contents

Pioneering ‘lighthouse farmers’ show that business models can be transformed

Always a multi-year transformation process at farm level

Today’s dominant business model:
mono-populations in optimized environment


- Commodity product → price is set on world market
- High and ever increasing input costs
- Asset intensive, ‘specialized technology rules’

→ Maximizing volume yields of ‘mono’ populations is the only way to earn a living income

Lighthouse farmers with diverse production have developed one or more of these competitive advantages:



- Differentiated products → price premium
- Much lower input costs
- Less asset intensive, ‘technology supports’
- Multi-product synergies (yields and/or costs)
- Revenues from ecosystem services
- Forward integration in short, local, value chains

We work with a community of practice of 20 farmers

A regenerative agriculture system can only be achieved in practice with a mosaic of innovative solutions.

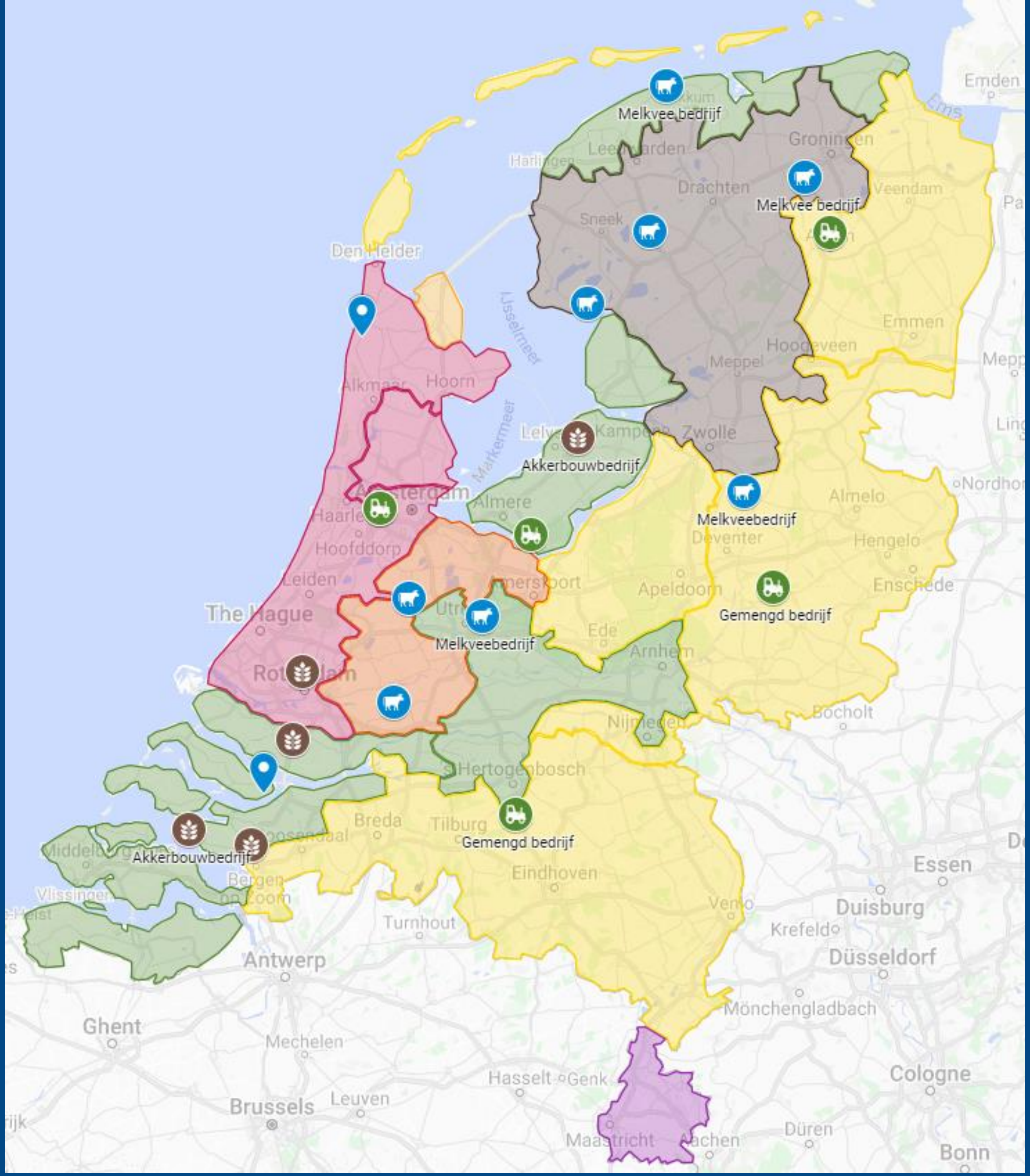
Therefore, the team of researchers cooperates with a community of practice of 20 farmers in the Netherlands. This community is set up

- to facilitate the sharing of best practices between farmers,
- to measure the impact of best practices and
- to help researchers to learn from farmers what systemic changes are needed to enable a transition towards regenerative agriculture.

Broad group of farmers

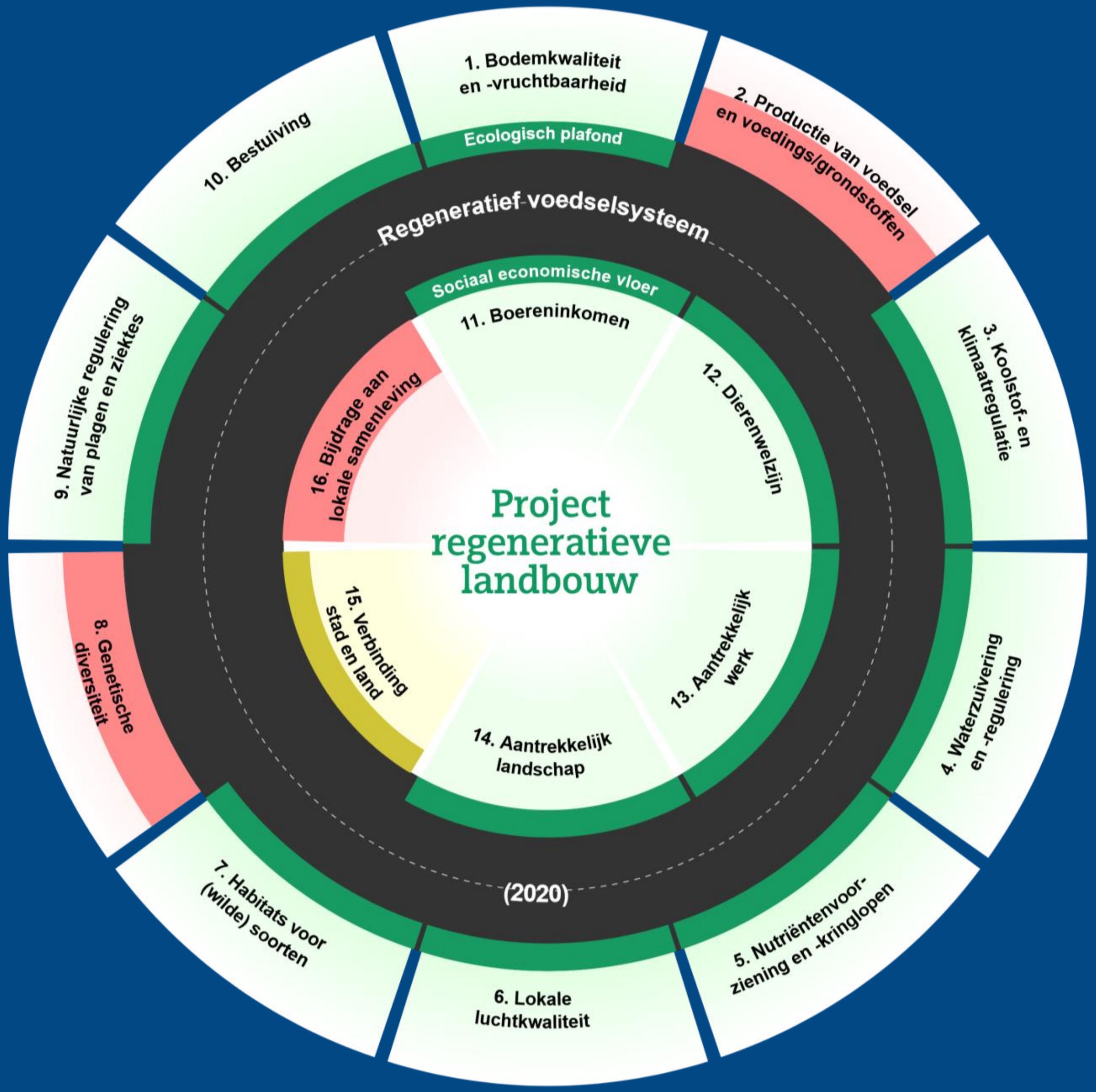
- Different soil types
- Dairy, Arable and mixed farms
- Ranging from 'Average' Dutch farms to >30 years experience with regenerative practices

See www.regenerativefarming.nl for more info



With the COP we ask self assessments and measure outcomes on all topics in the set of requirements

- ‘Donut’ method visualizes performance of participants on RF criteria
- Shows whether the farm stays within ecological boundaries and provides socioeconomic foundation
- First, a self-assessment of the current situation, the past (2000), and future goals → done
- In progress, objective measurement of the actual outcomes on each topic



Commonalities in community of practice – first impressions

- Holistic management of their farm
- Attention for soil health: soil life, soil structure and organic matter
- Continuous improvement and experimenting attitude: strong sense of doing something better each year
- Independent system thinkers,
  - reluctance towards following ‘reductionist’ advice from suppliers of feed, fertilizer, chemicals, antibiotics….

Contents

Work packages and tasks 2021-22

√ WP 1:
Brief of requirements for a regenerative agriculture system at scale (2019/20)

√ WP 2:
Taking stock of best practices to date (2018/19)

√ WP 3.1:
Taking stock of research questions for co-creation (2019)

WP 4: Design and model scenario's that meet the brief of requirements (proof of concept)

Landscape level:
- 4.2 Model regenerative landscapes, P3 Schreefel
- 4.3 Design regenerative landscapes (WUR-FT MSc projects, 2020/21)

Farm level:
- 4.1 Model regenerative farms, P2 Schreefel
- 4.4 Design regenerative farm systems, (WUR-FT MSc projects 2021/22)

WP 3 Action research 'regenerative practices' together with community of practice (app. 20 farms)

- 3.2 Measurement performance versus 'brief of requirements' at CoP farms (WEcR, U.U and FSE students)
- 3.3 Explore revenue models for ecosystem services (Groene Brein, Wojtynia)
- Optional for farmers: participate in design challenges (tasks 4.3 and 4.4)
- Selected research questions from COP, tbd

WP 5: Think-do gap and transition scenario's

- 5.1 Think-do gap: Identify system barriers for scale up, P2 Wojtynia
- 5.2 Scenario's, what could future agri-food systems look like, P3 Wojtynia (2021)
- 5.3 Transition scenario's and socio-economic levers for change, P4 Schreefel and Wojtynia

(Potential) projects building on the regenerative farming project

- Extend the CoP with early adopters (proposal in this year's TKI call)
  - To co-create viable transition plans at farm level, and trigger these plans to be executed
  - To co-create with public and private partners a plan for scale-up; enabling majority of farmers to become part of a regenerative system
- Develop supporting 'Technology for Ecology' (focus of Synergia and Agros programs)
- International scale up: Develop repeatable model for regenerative agriculture at landscape level, tailored to local ecosystems and societies.
- Combine the above three in a 'national growth fund' plan

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