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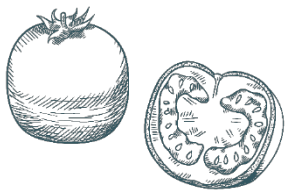
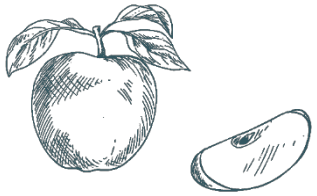
System-based breeding approach

Edwin Nuijten, LBI

Workshop 12-2-19, Biofach





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Why do we need system-based breeding?

1. Observations and trends
2. Framework of analysis
3. Concept of systems-based breeding

The scientific paper underlying this concept is:
Lammerts van Bueren E.T., Struik P.C., Van Eekeren N., Nuijten E. (2018) 'Towards resilience through systems-based plant breeding. A review'. Journal of Agronomy for Sustainable Development, 38: 42.

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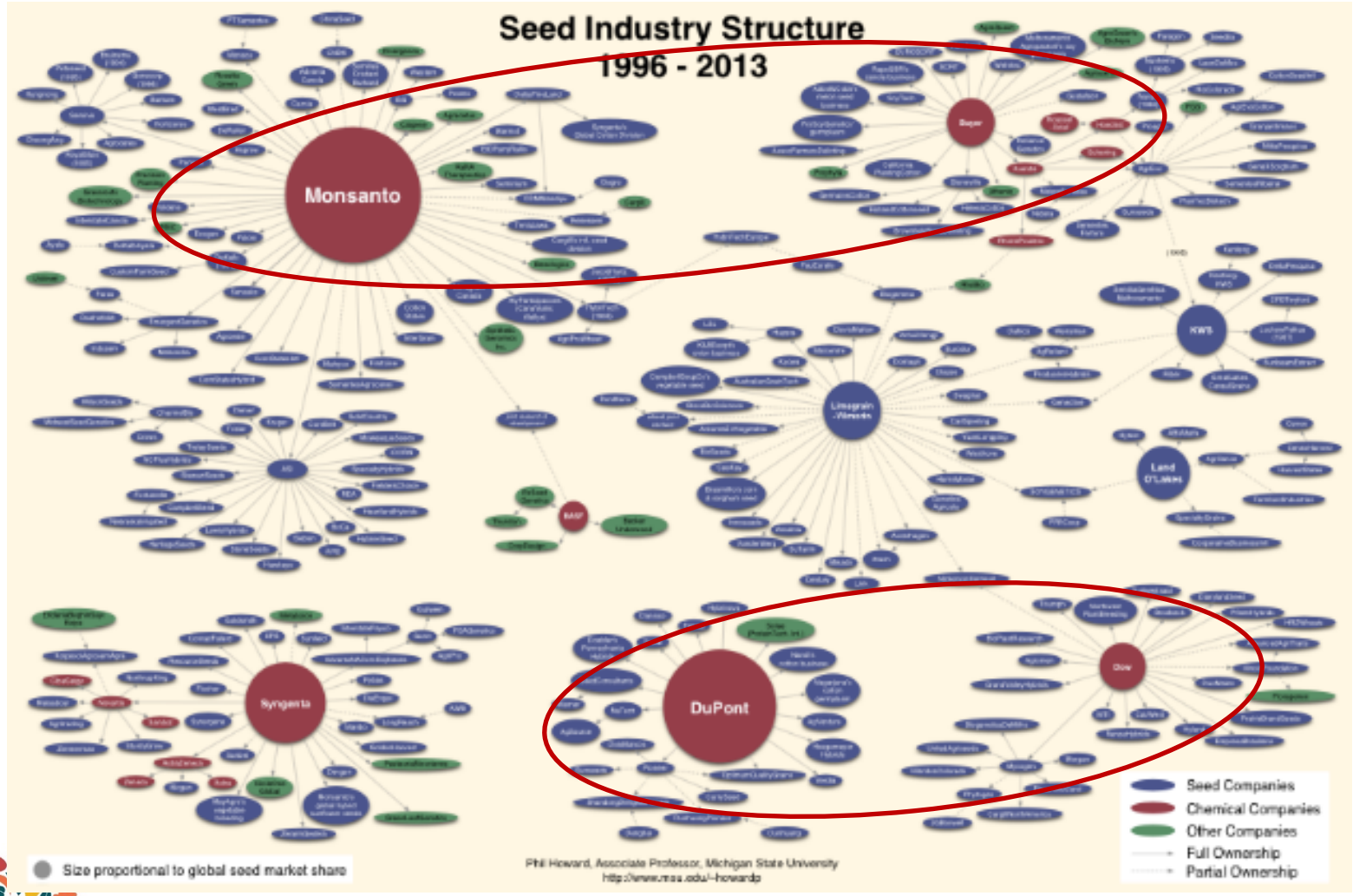
Some observations
How does the breeding landscape look like?



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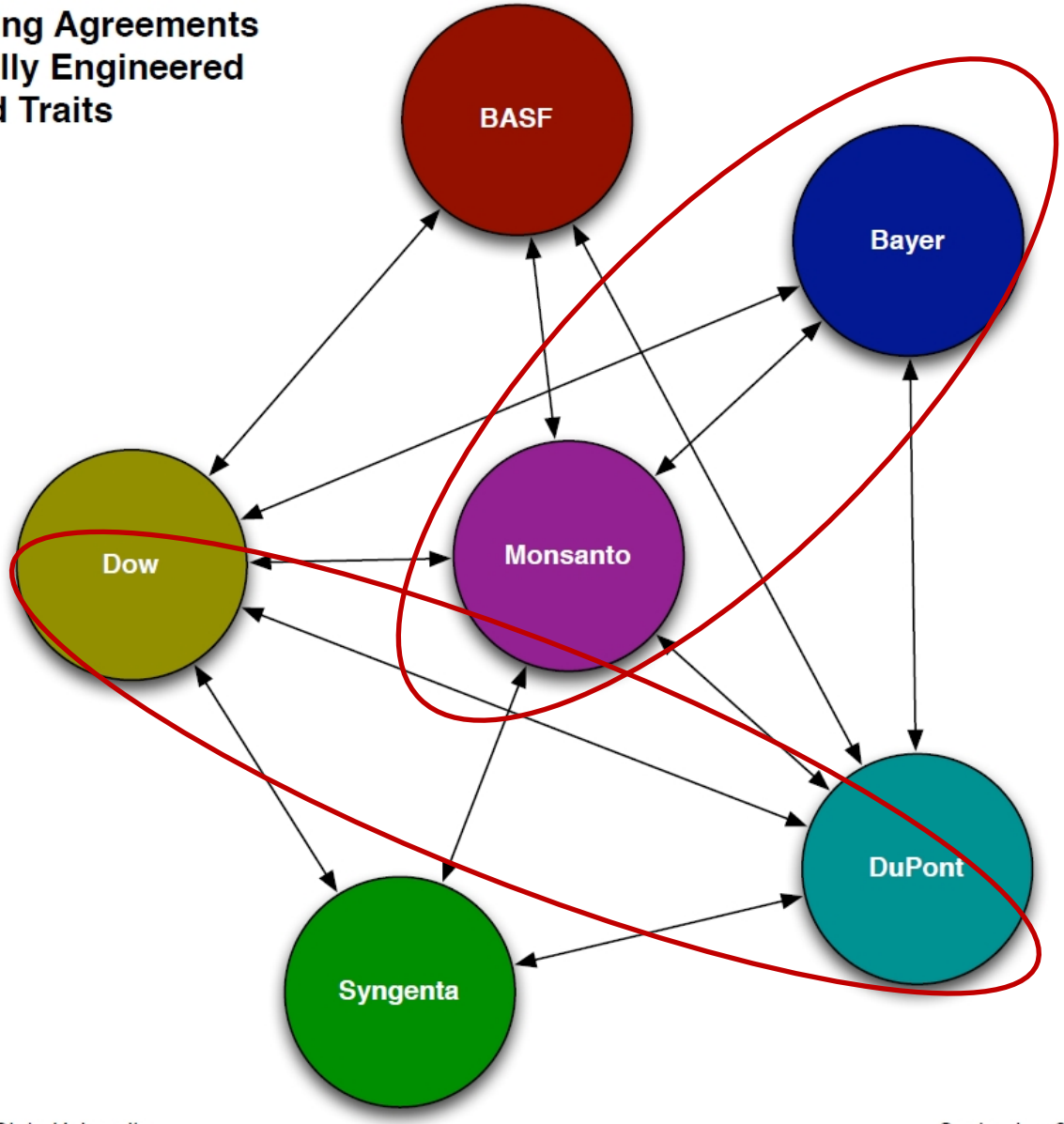
Cross-licensing Agreements for Genetically Engineered Seed Traits



Phil Howard, Michigan State University

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September 2013

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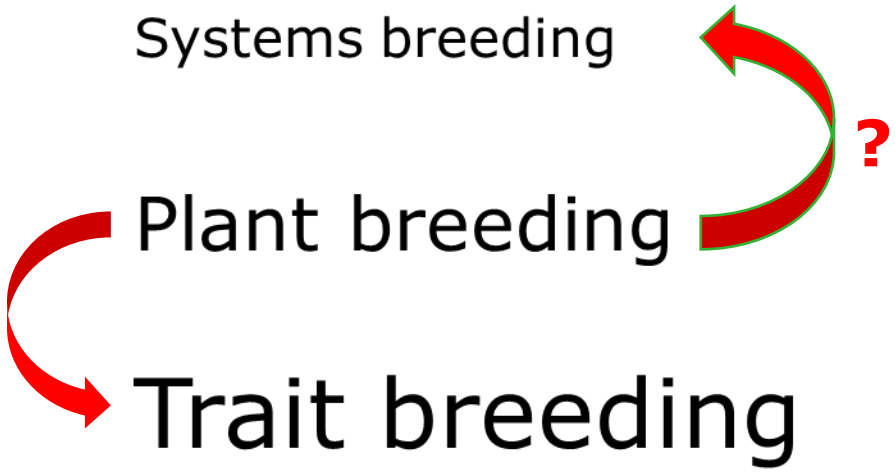
CPVO figures: Main vegetable applicants 2017 (until 07/09/17)

Applicant	Country	N° applications	% change 2016-2017	Ranking change
Monsanto Vegetable IP Management BV	Netherlands (USA)	91	- 20%	=
Rijk Zwaan Zaadteelt en Zaadhandel BV	Netherlands	63	- 24%	=
Enza Zaden Beheer BV	Netherlands	58	+ 14%	↑ 1
Nunhems BV	Netherlands	48	- 16%	↓ 1
Syngenta Seeds BV	Netherlands	47	+ 24%	=
Clause SA	France	34	+ 42%	↑ 2
Vilmorin SA	France	22	- 8%	=
Bejo Zaden BV	Netherlands	19	- 44%	↓ 2
Sakata Seeds Europe VB	Netherlands (JP)	10	+ 1000%	New entry
Semillas Fitó SA	Spain	6	+ 50%	New entry
Total applications	Till 7-9-17	440		

Trend 1:
Trait breeding

More and more plant breeding is becoming trait breeding



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Patents on plant traits and use of Male Sterility in F1-hybrids

Family	English Name	Use patents	Male sterility; PF = Protoplast Fusion
Fabaceae	Beans		NA
Fabaceae	Broad bean		NA
Fabaceae	Pea	Yes	NA
Compositeae	Lettuce	***Yes***	NA
Compositeae	Chicory	Yes	Yes, PF
Compositeae	Sunflower	Yes	Yes
Chenopodiaceae	Spinach	Yes	
Chenopodiaceae	Beetroot		Yes
Cucurbitaceae	Pumpkin / Zuchinni (C. pepo)	Yes	
Cucurbitaceae	Pumpkin (C. maxima)		
Cucurbitaceae	Cucumber	Yes	
Cucurbitaceae	Melon	Yes	
Cucurbitaceae	Watermelon	Yes	Yes
Crucifereae	Head cabbage	Yes	Yes, PF
Crucifereae	Cauliflower	Yes	Yes, PF
Crucifereae	Broccoli	Yes	Yes, PF
Crucifereae	Chinese cabbage		Yes, PF
Alliaceae	Onion	Yes	Yes
Alliaceae	Leek	Yes	Yes
Solanaceae	Tomato	***Yes***	
Solanaceae	Sweet Pepper	***Yes***	(Yes)
Solanaceae	Pepper	Yes	(Yes)
Umbellifereae	Carrot	Yes	Yes
Umbellifereae	Celery		Yes
Umbellifereae	Fennel		Yes

Trend 2:
Loss of small crops in breeding

- National diets are becoming more diverse, world wide diets are increasingly more similar (*Khoury et al. PNAS 2014).*
- Of the 30.000 edible species we grow only 150,
- 95% of our human food calories originate from 30 crop species *(WHO & CBD, 2015*)
    - Small crops are orphans in breeding
    - Breeding should put more efforts into improving small crops!

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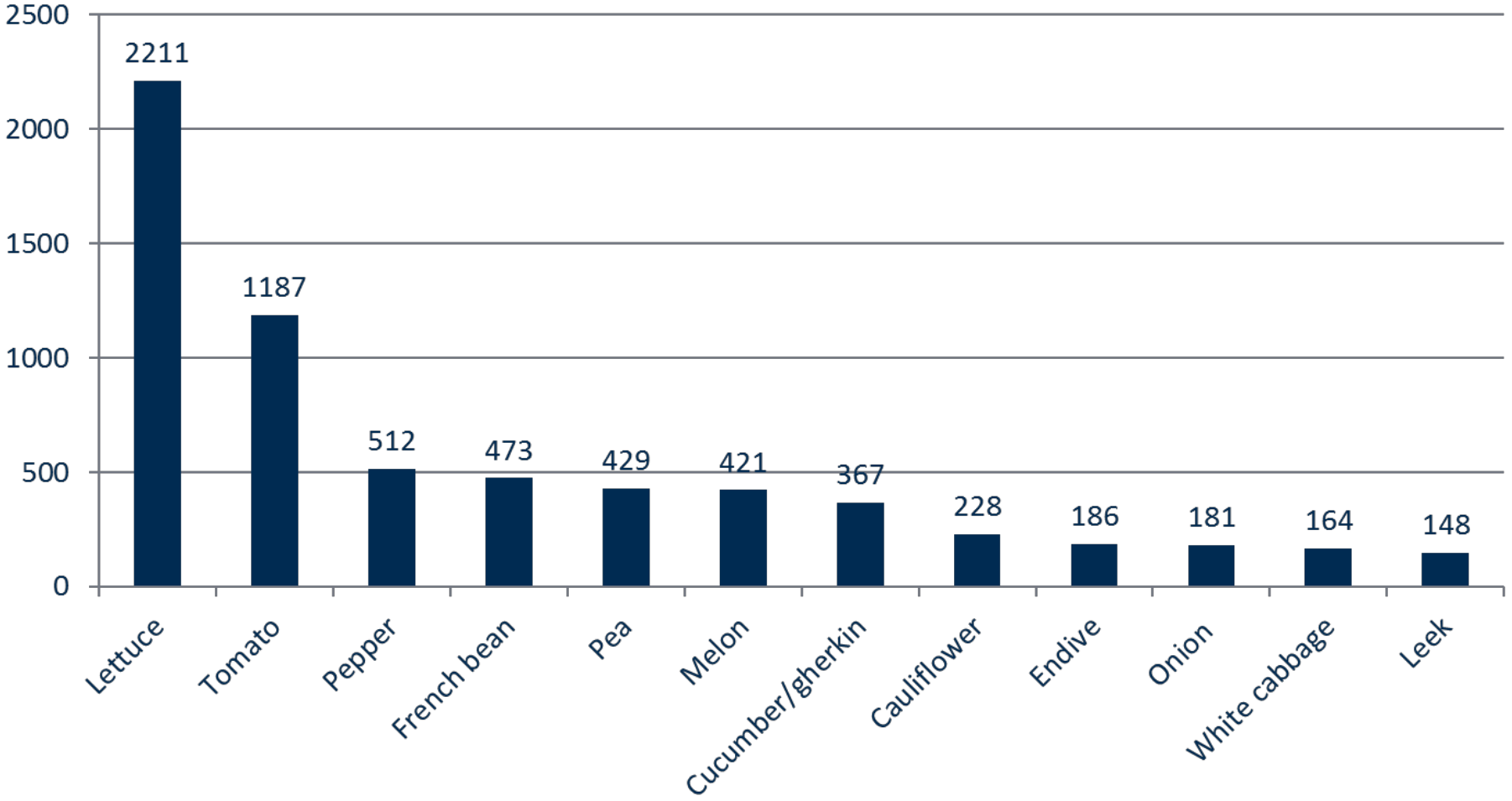
CPVO: Main species in vegetable sector per number of applications (1995 – 4 November 2016)



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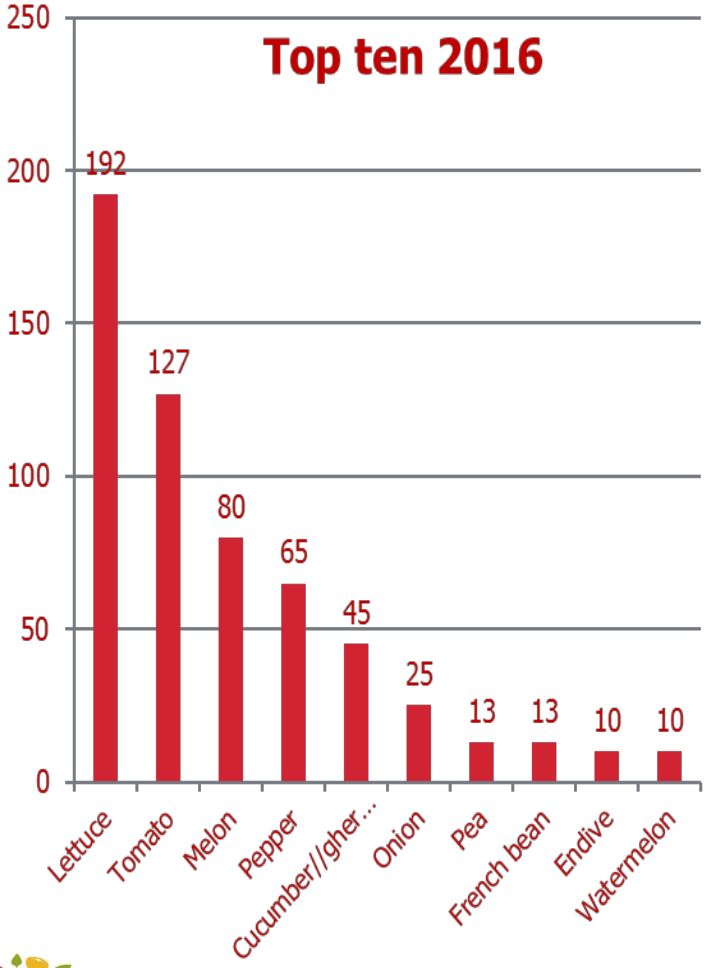
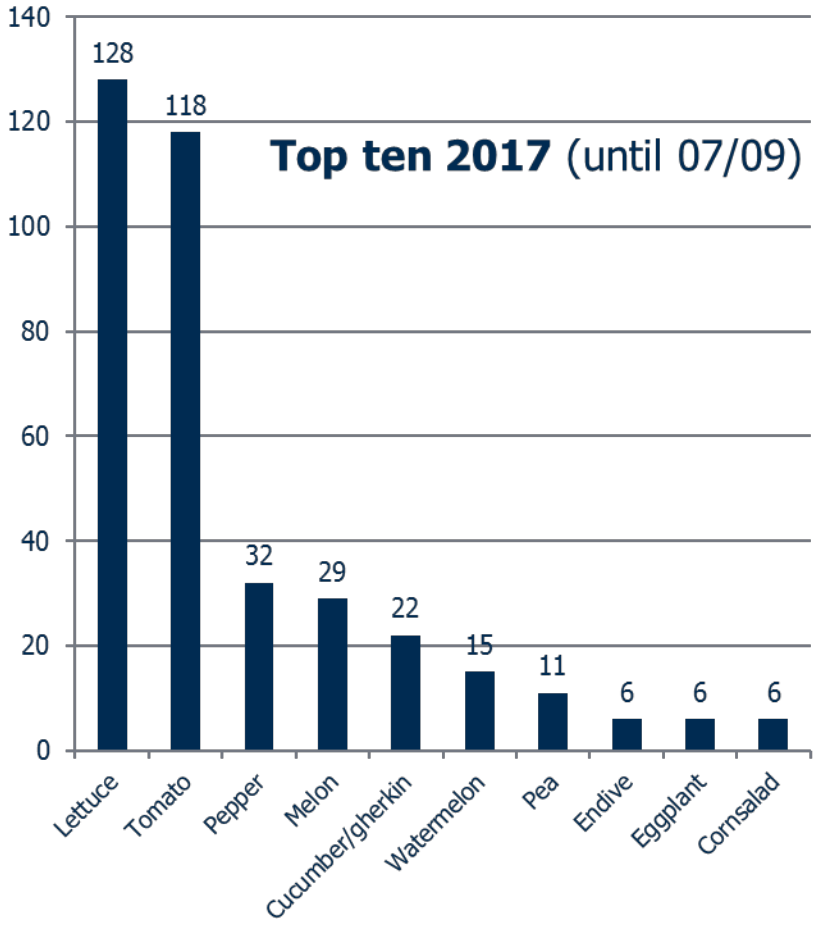
CPVO: Number of applications in the vegetable sector per crop





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Trend 3:
Breeding for (longterm) ecosystems services?

- Biodiversity and ecosystems services are key factors that contribute to:
  - natural pest control
  - pollination
  - nutrient (re)cycling
  - soil conservation (structure and fertility)
  - water provision (quality and quantity)
  - carbon sequestration

Genetic variation in root biomass in grass (Lolium multiflorum). Deru et al. Euphytica 2014

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Trend 4:
Organic 3.0 (IFOAM 2015):
Broadening the organic scope

How to transform those criteria into breeding?

dimensions:

- Ecology
- Society
- Culture
- Accountability
- Economy

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Trend 5:
SDGs of UN - targets for ecological and societal resilie

- Publis[illegible] 2015

How to integrate those goals into breeding?

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Trend 6:
New developments in organic breeding

- Breeding for diversity:
  - Composite Cross Populations (CCPs)
  - Suitability to mixed cropping
  - More diversity within varieties
- Initiatives in breeding with involvement of the value chain
- Opening up of seed laws: new possibilities

How to foster these developments?

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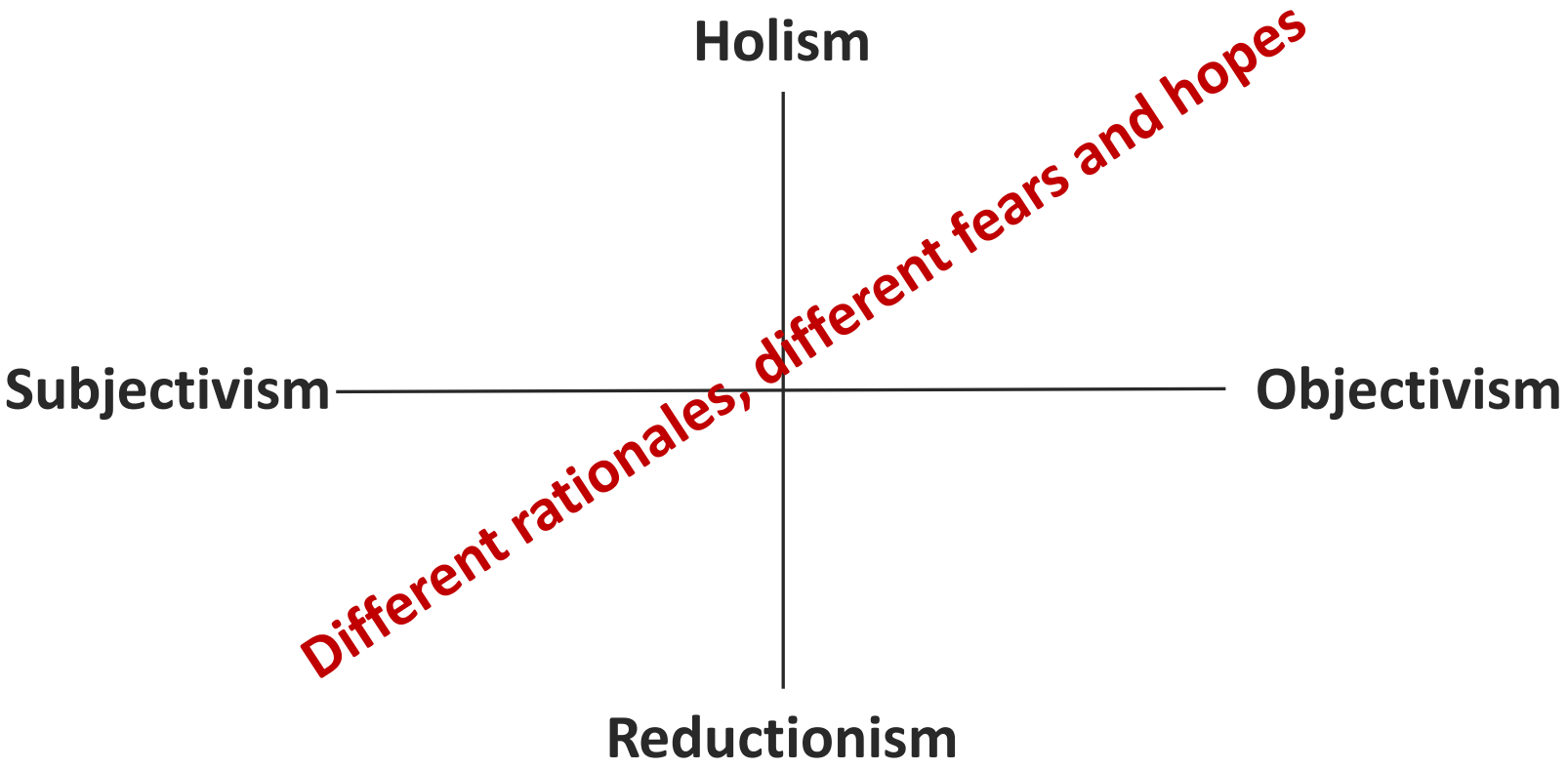
Framework of analysis
(adapted after Bawden, 2010)



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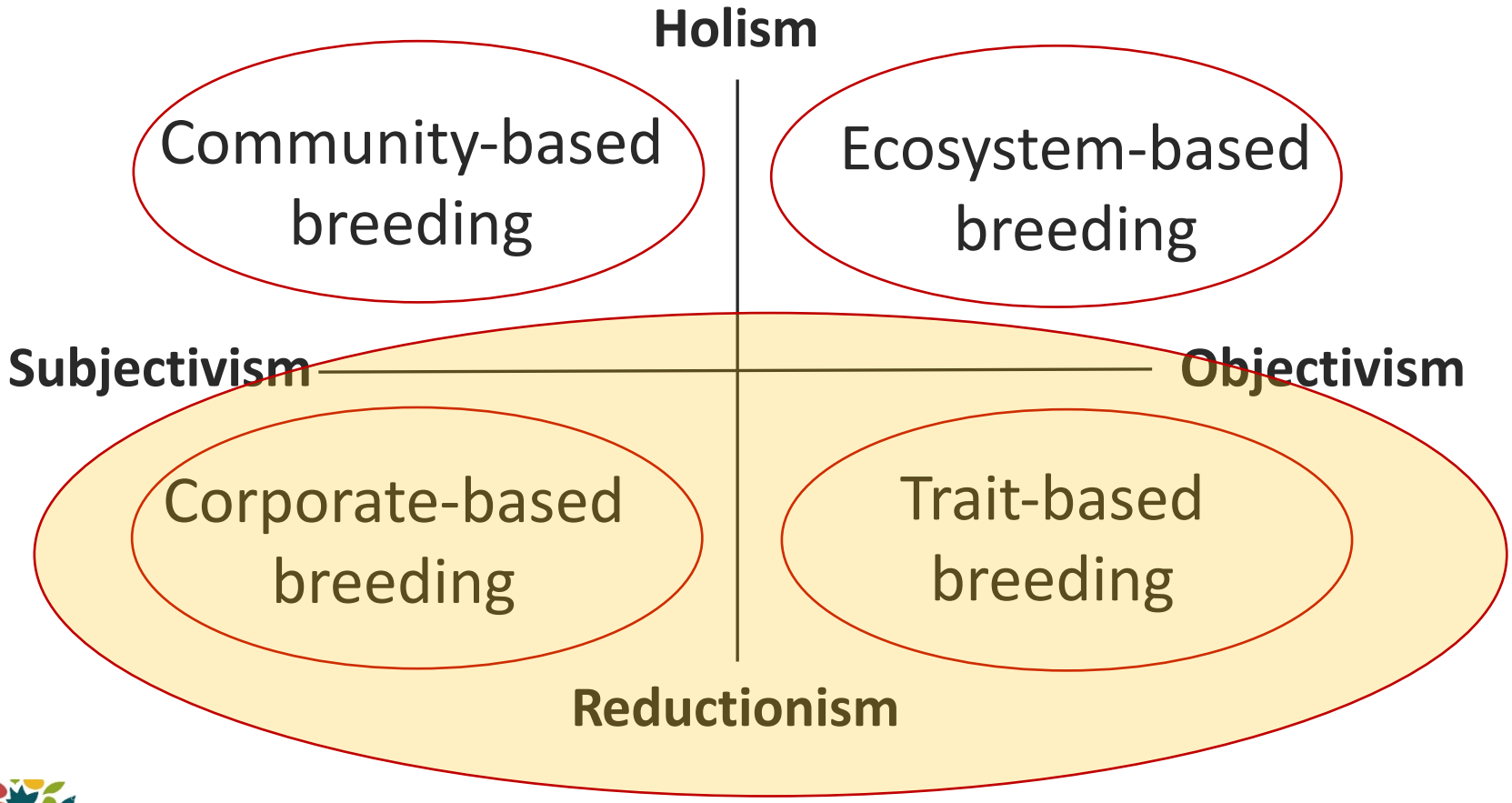
Four breeding orientations (paradigmatic positions)



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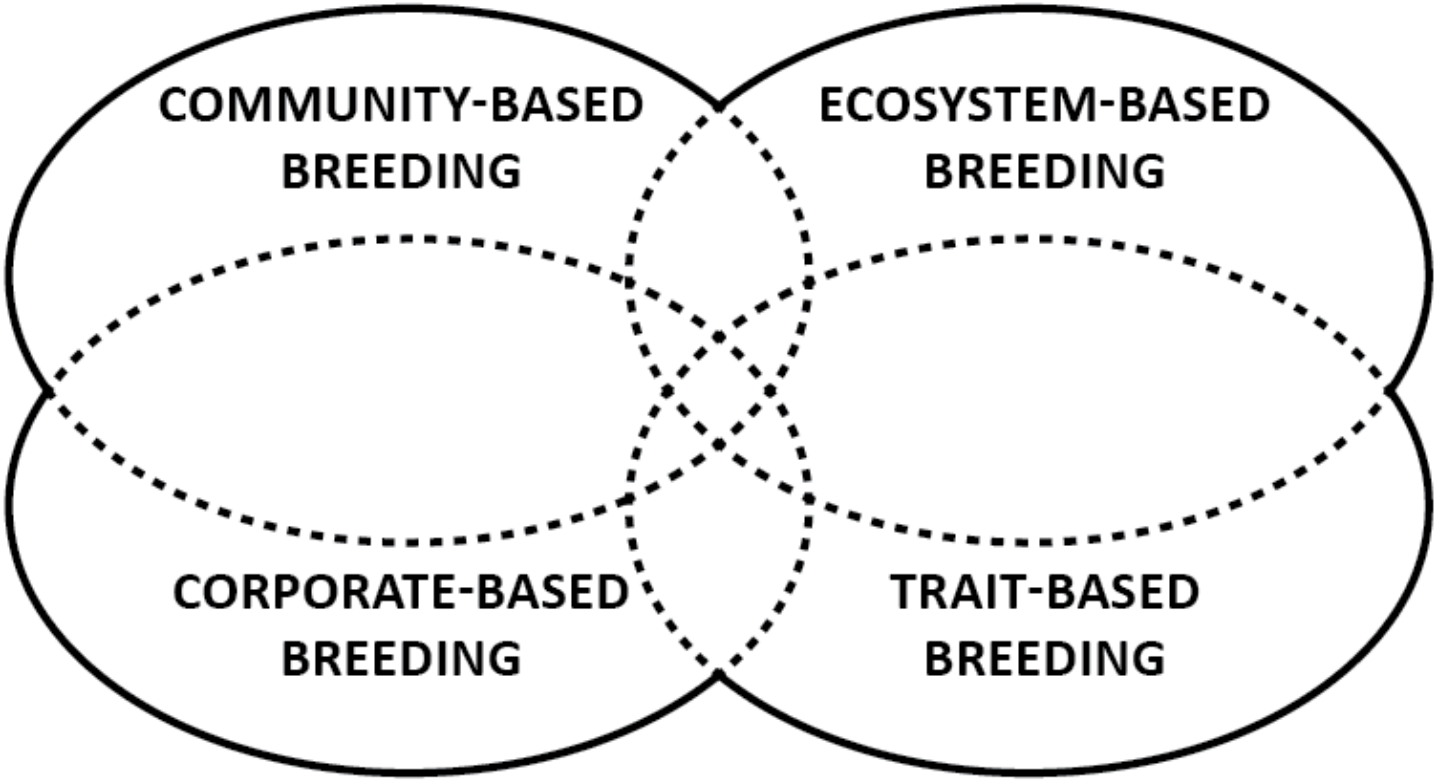
Each position has strengths and weaknesses
Need for optimal interaction and synergy



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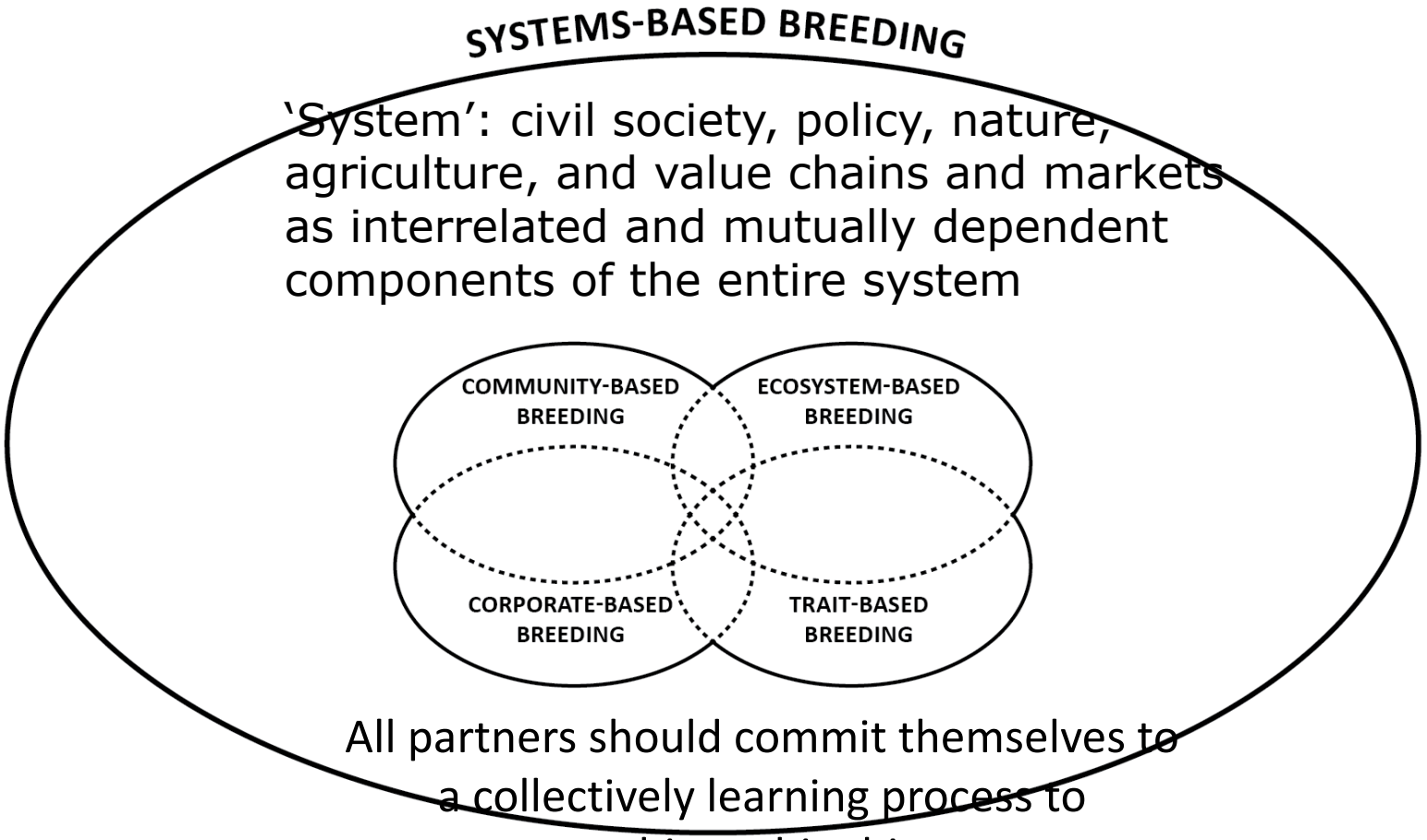
5th breeding orientation: systems-based breeding



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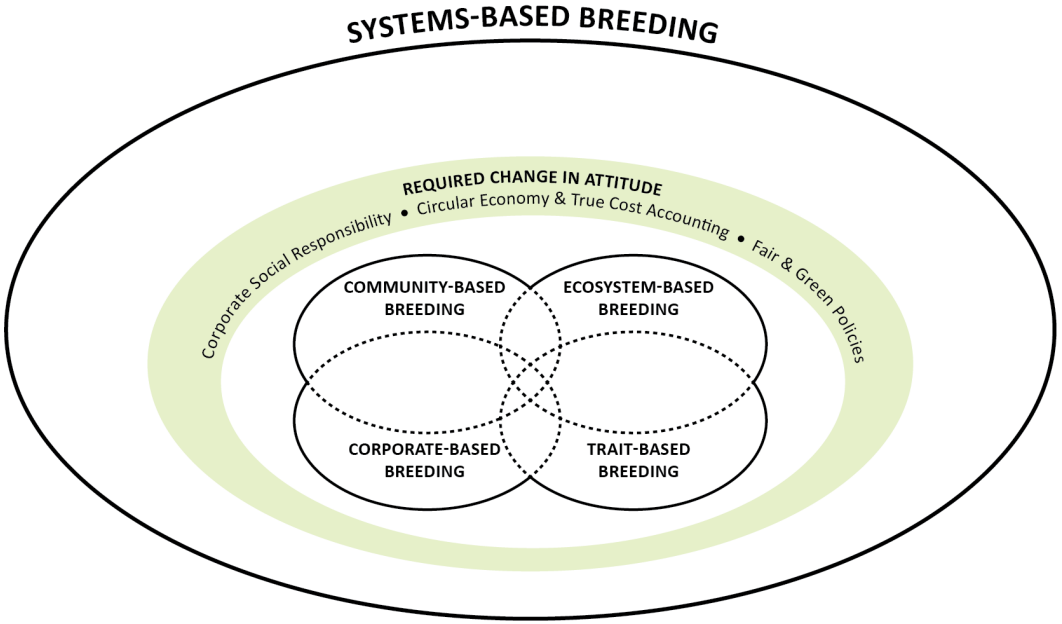
Required change in attitude



Three key-elements

1. Corporate Social Responsibility
2. Circular Economy & True Cost accounting
3. Fair & Green Policy

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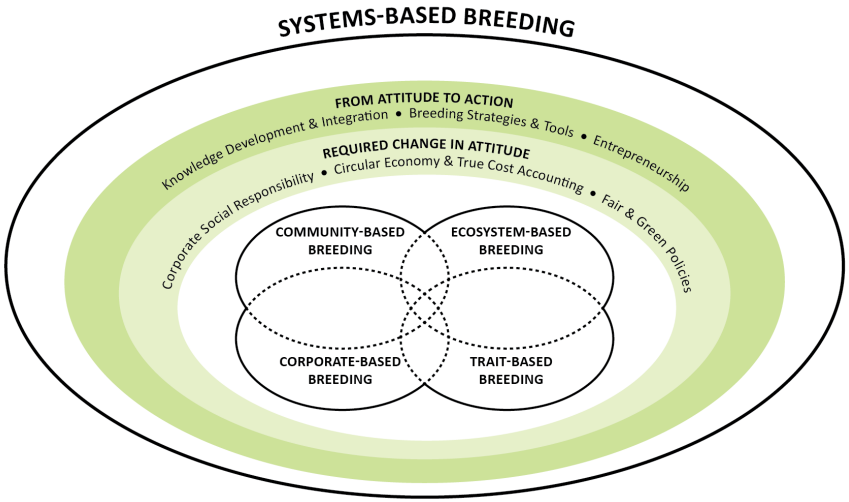
From attitude to action



Three key-elements:

1. Knowledge development & Integration
2. Breeding strategies & Tools
3. Entrepreneurship

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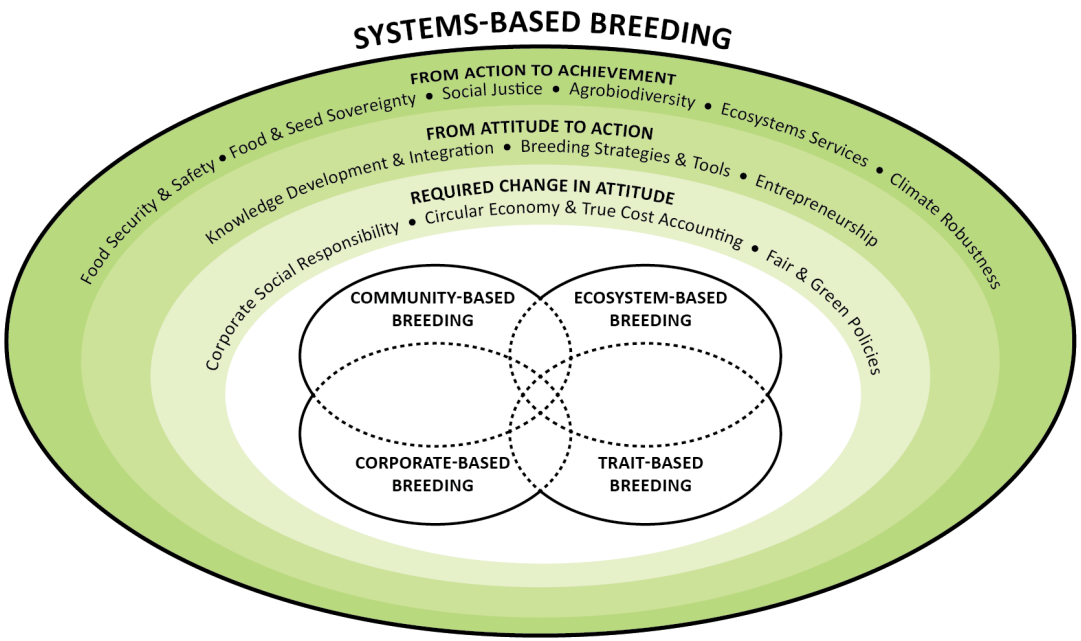
From action to achievement: 6 goals



Six key-elements (goals):

1. Social justice
2. Food quality, security and safety
3. Food and seed sovereignty
4. Agro-biodiversity
5. Ecosystem services
6. Climate robustness

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