資料２

Opportunities and Challenges for Agricultural Innovation Systems: emerging responses to Agriculture 4.0 and Agrifood System Transformation（農業イノベーションシステムへの課題と機会：農業4.0と食農システム変換への新たな対応）

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PRIMAFF
Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries

Tokyo, 22 January 2020

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Agricultural innovation and Japan

農業イノベーションと日本

10 | The Japan Times | Tuesday, January 1, 2019

new year special

Agriculture innovating to secure future

Farms rethinking hiring, benefits in bid to attract and retain employees

KYODO

Decades ago, small family operations dominated Japan's agriculture industry, but today, the gradual shift to large-scale farming is creating many new challenges.

Facing a labor shortage and a rapidly aging workforce, the industry is trying to make its business more attractive to newcomers,

OECD Food and Agricultural Reviews

Innovation, Agricultural Productivity and Sustainability in Japan

McKinsey&Company

Empowering Japanese agriculture for global impact

McKinsey Japan October 2016

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What will I talk about 本日の報告内容

1. Changing views on innovation- towards systemic approaches
2. Agriculture 4.0 and food system transformation
3. Implications for organizing co-innovation

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1. Changing views on innovation- towards systemic approaches

イノベーション研究における視点の変化-システムアプローチに向けて

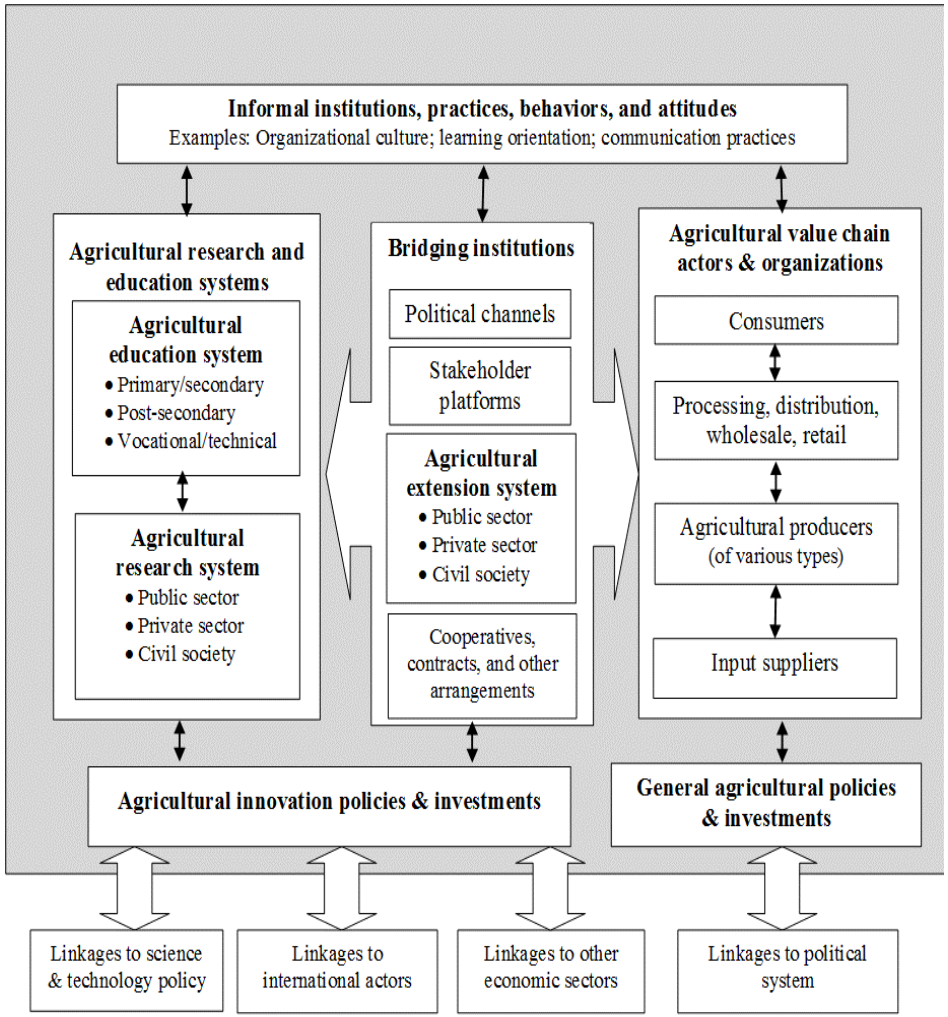
Chapter 5. Agricultural innovation systems in Japan

Innovation policy is moving beyond supply-driven approaches that focus on R&D and specific technologies to a network-based setting, in which a more inclusive, interactive, and participatory approach fosters greater innovation in response to pressing challenges facing the food and agriculture systems. This chapter describes the agricultural innovation system in Japan and outlines the recent changes it has undergone. It provides an overview of the general innovation system, presents agricultural innovation actors and governance of the innovation system, outlines changes in roles and themes of R&D, and presents the main policy instruments and monitoring efforts. It then reviews the main trends in public and private investments in R&D, the funding mechanism, as well as the means used to foster knowledge markets and networks.

Where have we come from in understanding agricultural innovation?

農業イノベーションへの理解、どこから派生？

- From the linear adoption and diffusion model..
- ...to Agricultural Innovation Systems...
- ... that may support sustainability transitions.



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Adoption and diffusion perspective

「採用と普及」の考え方

Still often held view:

- Innovations = technologies
- Innovations come from outside (from research)
- Innovations are communicated by extension
- Innovations are adopted by individuals

Fundamental science -> applied science -> education & extension -> farmers

Adoption and diffusion thinking: key criticisms

採用と普及の考え方：主な批判

- Introduced technologies are not adapted to the context and logic of those who are supposed to adopt (one-size-fits-all)
- Individuals cannot adopt (even if they know and want to)
- No effort made to adapt the context to the technology
- So an individual oriented perspective is sometimes inappropriately used for innovations which require multiple changes at multiple levels

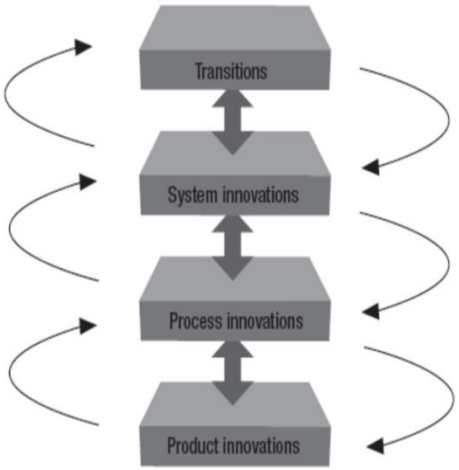

Figure 4.5 Cascade of innovations (Rotmans 2005)

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Two systemic perspectives

システム論からの二つのアプローチ

- Agricultural innovation systems: focuses on the organization and management of multi-actor innovation processes
- System innovation/transition perspective: focuses on the enablers and barriers, and dynamics and politics of transformative change
- However, boundaries between the two persepective are often blurred - but they are rarely connected

Agricultural Systems 164 (2018) 116–121

Contents lists available at ScienceDirect

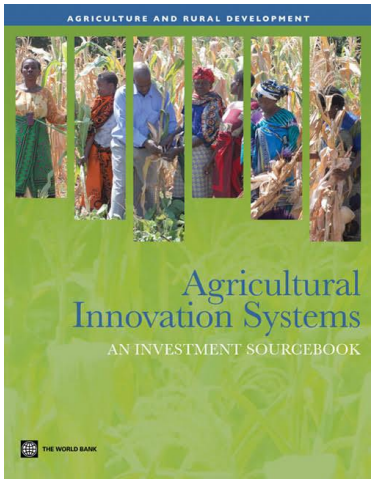
Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Beyond agricultural innovation systems? Exploring an agricultural innovation ecosystems approach for niche design and development in sustainability transitions

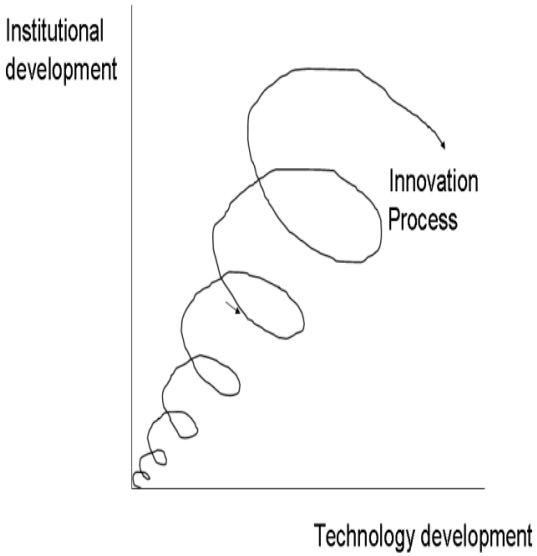
Ashlee-Ann E. Pigford[a], Gordon M. Hickey[a], Laurens Klerkx[b,*]

[a] Department of Natural Resource Sciences, Faculty of Agricultural and Environmental Sciences, McGill University 21,111 Lakeshore Ste-Anne-de-Bellevue, Quebec H9X 3V9, Canada



Agricultural Innovation Systems (AIS) perspective 農業イノベーションシステム（AIS）の考え方

- Emphasizes role of multiple actors and institutions, and innovation as *institutional change* next to technological change
- ‘a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge’. (World Bank, 2006)



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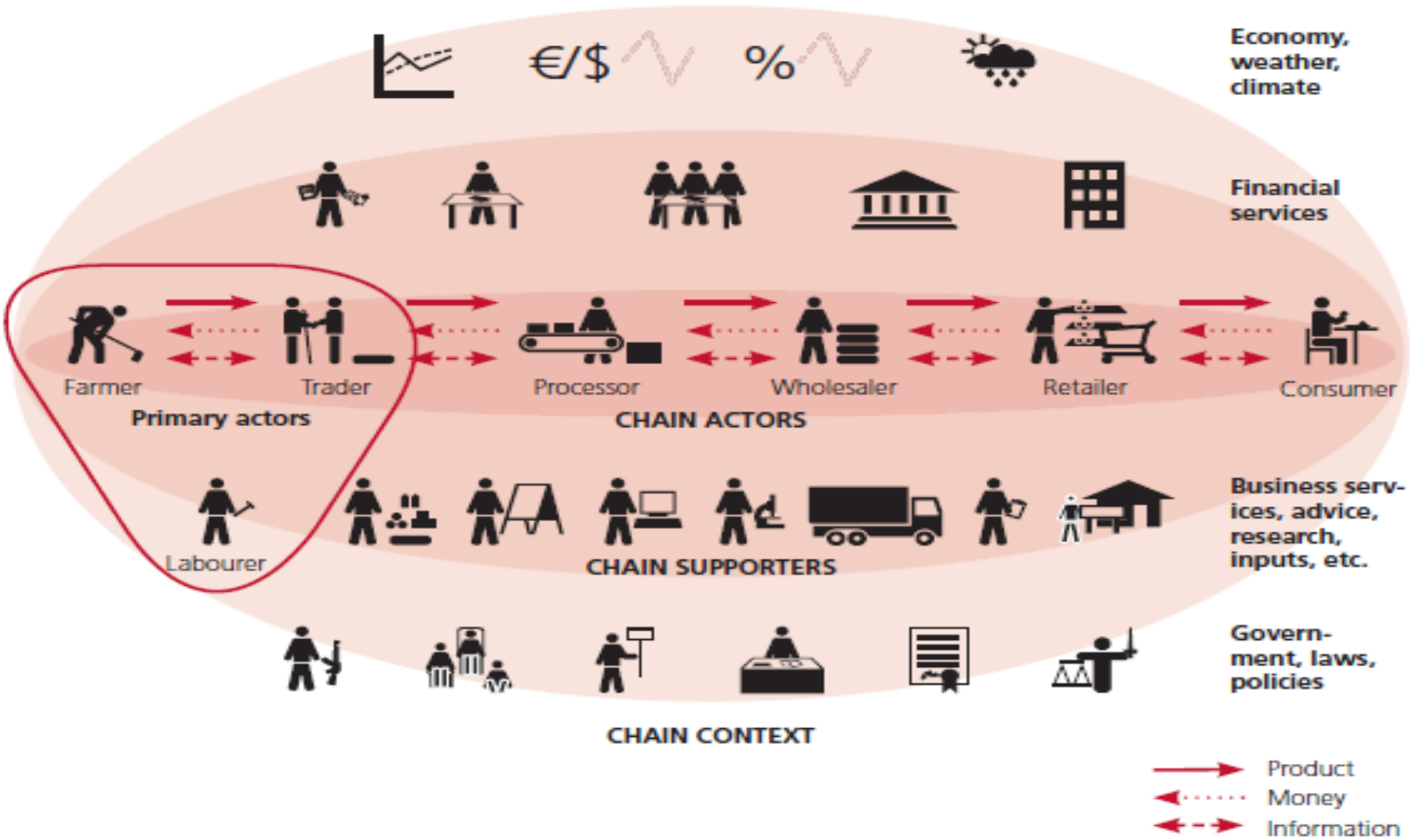
AIS emphasizes need to consider the full chain and create interaction throughout the chain

AISでは、すべてのチェーンを考慮する必要性、
そしてチェーン内で相互作用が生まれる点を強調



Source: Adapted from KIT and IIRR (2010)

Functions of innovation systems approach
イノベーションシステムアプローチの機能

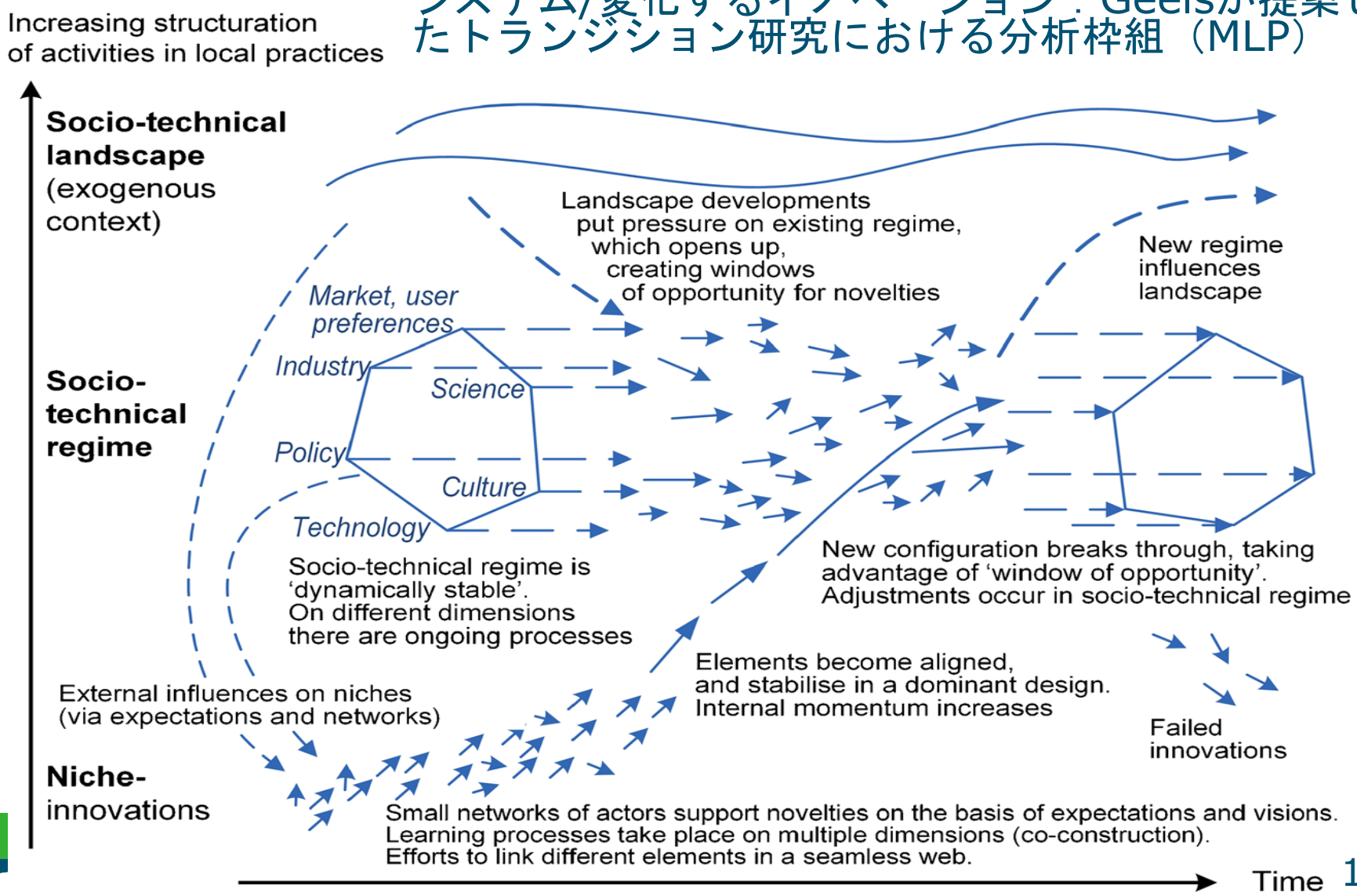
- Broadens the view on innovation systems beyond knowledge and interactive learning
- Is focused on what the collective work of actors in an IS should 'produce' in order to make innovation possible
- Hekkert et al. (2007): provide insights in the interaction of forces that determine the slow and difficult change of a merely locked-in system towards a new equilibrium

7 Functions 7つの機能

1. Entrepreneurial activities: business venturing & championing
2. Guidance of the search: interactive vision making
3. Knowledge development: R&D at different places
4. Knowledge sharing in networks: learning and experimentation
5. Resources mobilization: financial and human capital
6. Market formation: making markets for innovations or supporting them
7. Creation of legitimacy/overcoming resistance to change

System/transformative innovation: multi level perspective (MLP) on transitions (Geels)

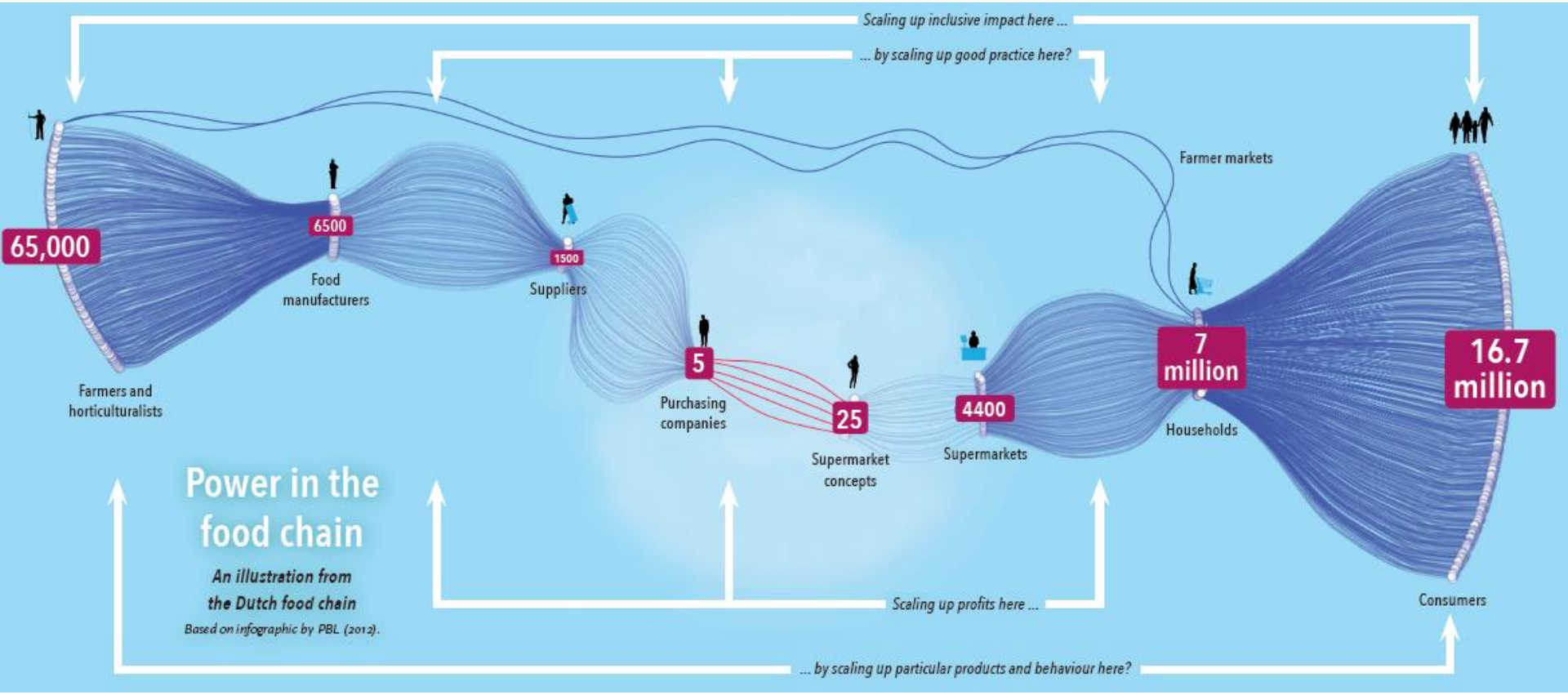
システム/変化するイノベーション：Geelsが提案したトランジション研究における分析枠組（MLP）



Variety in niches: e.g., alternative proteins

多様なニッチ：代替タンパク質の例

Power: it matters who and what drives innovation パワー関係：誰が、何がイノベーションを起こすのかが重要



Source: Wigboldus and Brouwers, 2016

Who decides what is innovated and goes to scale in food systems?

E.g. industrial agriculture? Or agro-ecology?

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Transition and transformation

トランジションとトランスフォーメーション

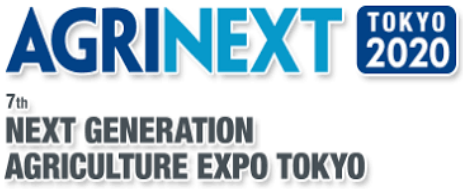
- Transition and transformation are key pillars of policy agendas worldwide
- Different drivers: both natural, economic, and technological
- Some of these have a (potentially) disruptive nature and affect power balances
- May affect both agricultural sector and AIS 'regimes'

Summary まとめ

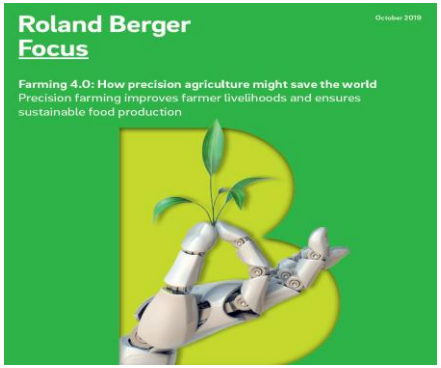
- Innovation and transition is not just technological change, but social, institutional and organizational restructuring
- Change in agricultural sector is part of broader food system change (and also fibre, bioenergy, etc.)
- Food system transformation needs work beyond the farm level
- Multiple types of persons & organisations needed – working across scales and functions in food systems
- Collaboratively working on change through networks (niches/regimes)

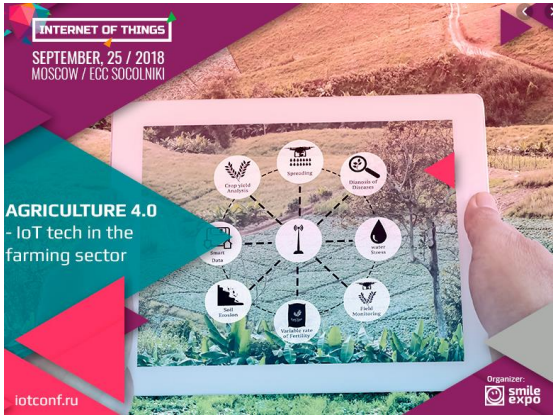
2. Agriculture 4.0 and food system transformation

農業4.0と
フードシステムトランスフォーメーション



7th
NEXT GENERATION
AGRICULTURE EXPO TOKYO





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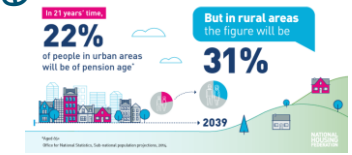
Several major challenges, developments and trends are influencing agriculture

主要な課題、開発、トレンドが農業に影響を与えている



- Growing demand for food, fibre and energy
- Climate change, resource degradation
- Growing middle class and more critical consumers
- Ageing rural population and decline in some places, rural population growth in other places – but farm succession issues virtually everywhere
- Corporatization of agriculture versus family (smallholder) farms, specialization vs multifunctionality
- Shift towards food systems approach and new Agriculture 4.0 technologies & concepts coming in (vertical, circular, regenerative, digital, synthetic ...)

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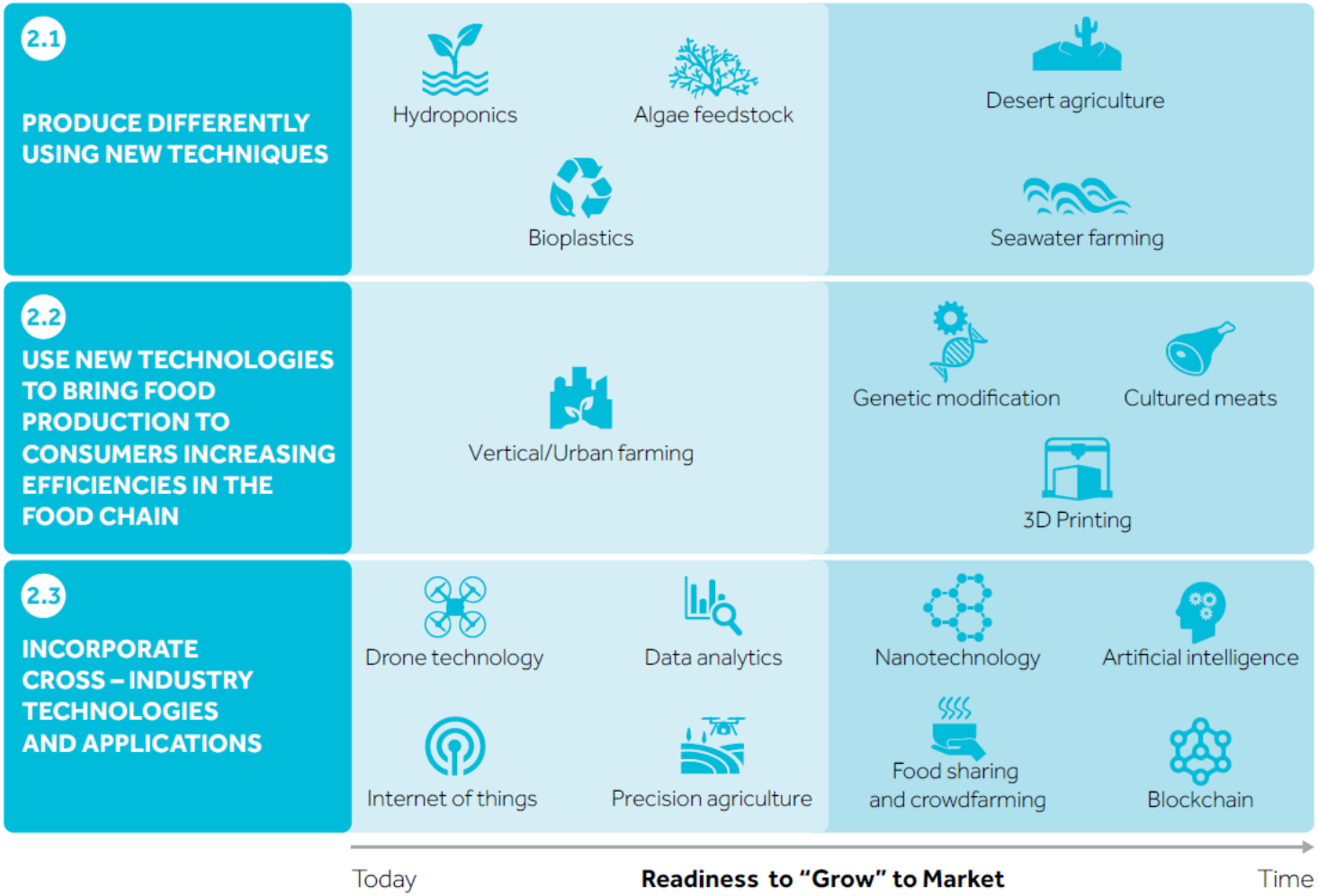
Agriculture 4.0 technologies and maturity

農業4.0の技術とその成熟度

MAP OF TECHNOLOGIES AND MATURITY



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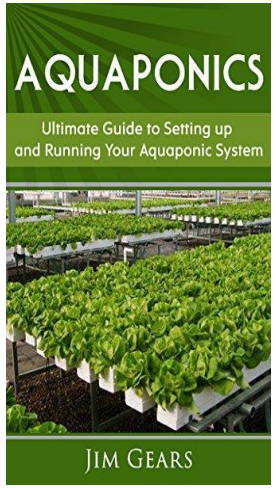
Source: DeClerq et al., 2018

Agriculture 4.0 and plurality

農業4.0とその多元性

- Transformation and disruption are not value free and have (competing/collaborating/co-existing) networks of actors and underlying values, visions and paradigms: *sustainable intensification, ecological intensification, agriculture 4.0, circular agriculture, vertical agriculture, regenerative agriculture, nature inclusive agriculture, etc.*



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Plurality of agriculture in Japan

日本における農業の多元性

RICE DUCKING

Rice ducking is a system of rice production invented by a Japanese farmer, Takao Furuno. By releasing ducks into rice paddies, Furuno has achieved a higher rice yield with much less labor and financial outlay, while at the same time maintaining environmentally sustainable agriculture. Advantages are that the ducks eat weeds (which means weeds do not need to be removed by hand), they also eat insects, the ducks' droppings provide nourishment for the

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Japan's Urban Agriculture: Cultivating Sustainability and Well-being

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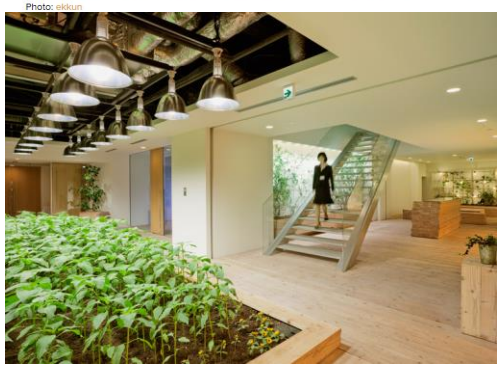
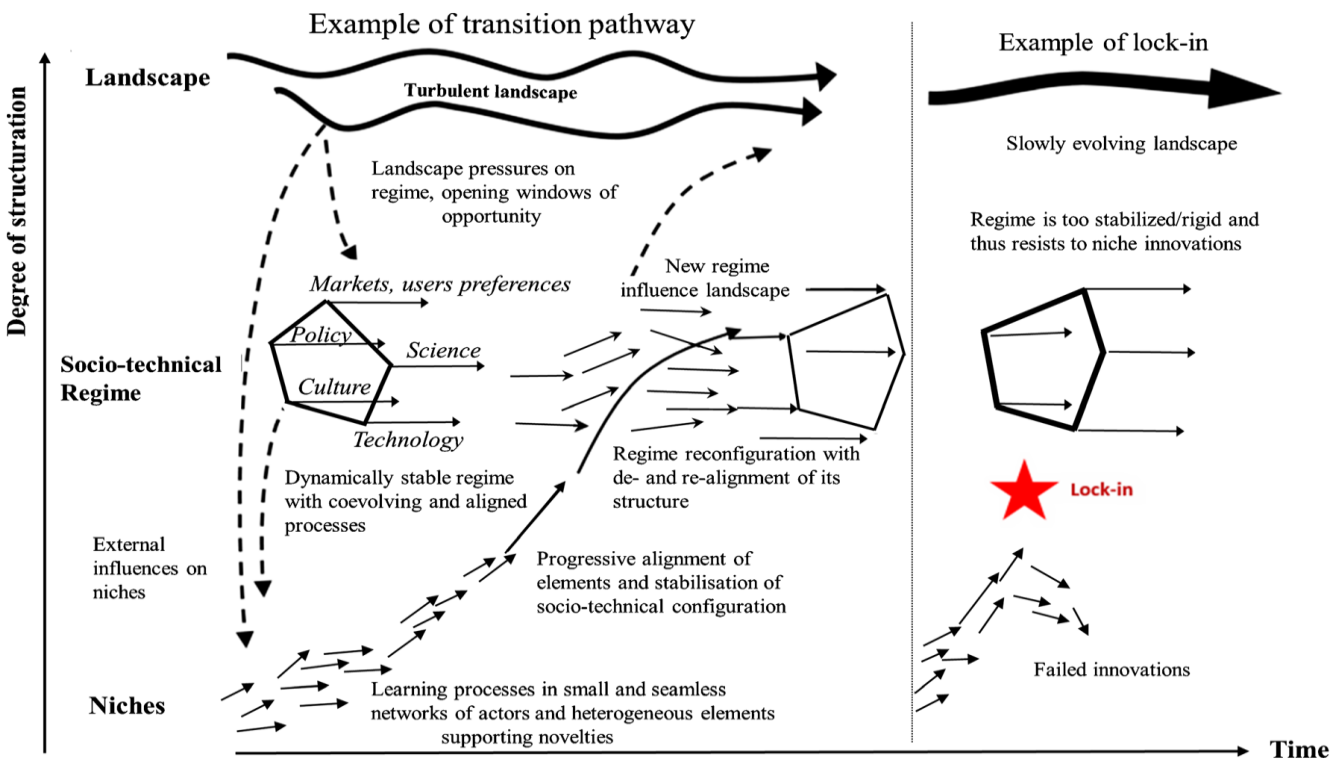


22

Are Agriculture 4.0 technologies niches or part of food system regimes? How transformative are they?

農業4.0の技術は、ニッチなのかフードシステムレジームの一部なのか？どのように変化している？



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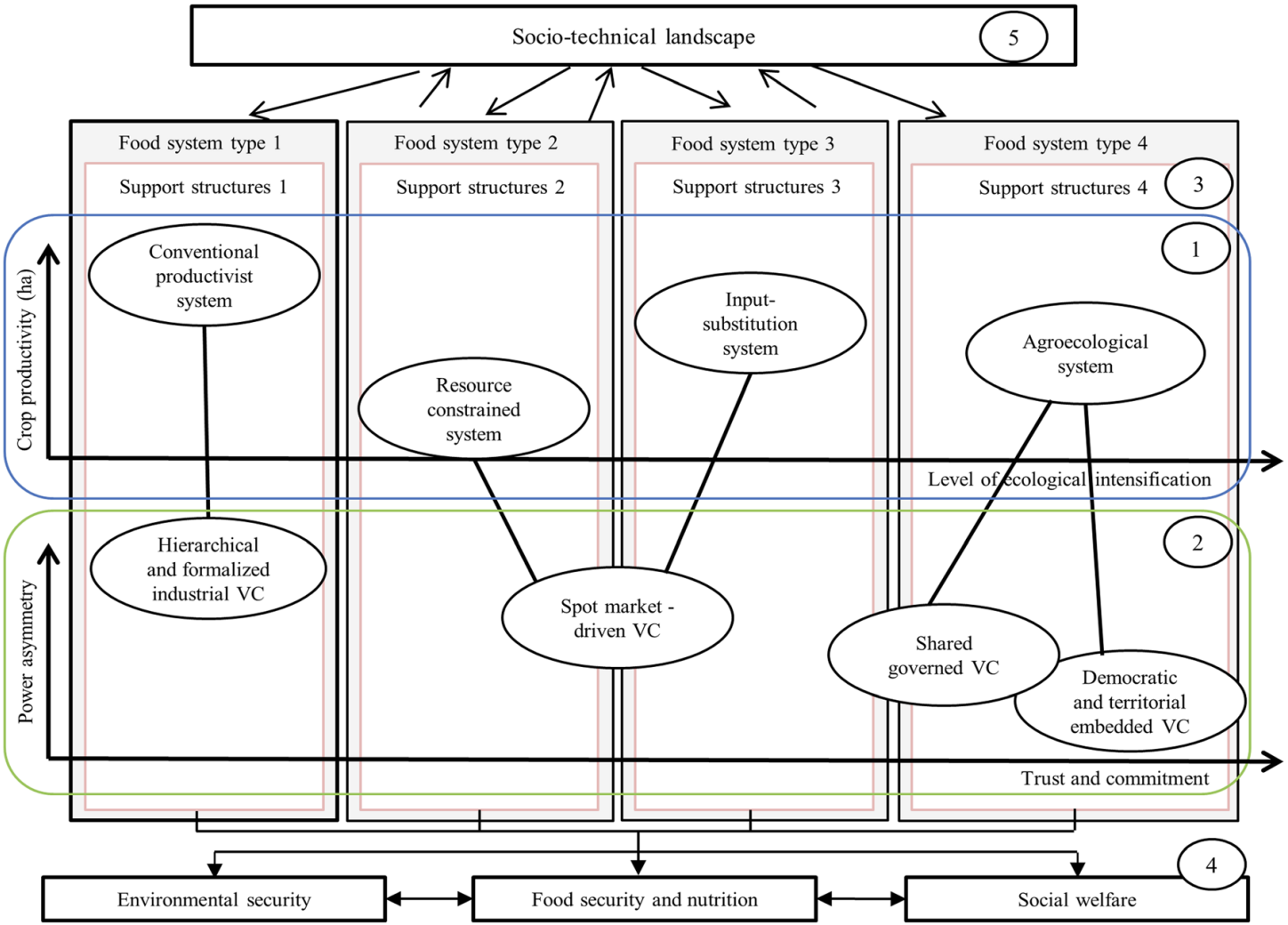
Mapping food system(s) diversity

多様なフードシステムのマップ化



Source: Gaitán Cremaschi et al., 2019

‘Dark side’ of Agriculture 4.0

農業4.0の暗黒面

- Advocates emphasize often economic and environmental gains, however Agriculture 4.0:
  - May be incompatible with people’s values (e.g. genome editing)
  - May have unknown and unseen effects which become visible when going to scale (e.g. nanoparticles)
  - May have inclusion and exclusion effects with social repercussions (e.g. data ownership, farmer deskilling, farmer identity related to digital agriculture)

THE DARK SIDE OF DIGITALIZATION: WILL INDUSTRY 4.0 CREATE NEW RAW MATERIALS DEMANDS?

The digitalisation of production and the ‘Internet of Things’, referred to as Industry 4.0 in Europe, is being sold with the promise of ‘clean’ economic growth and resource efficiency in a time of converging eco-social crises.

But although the new technologies making this ‘fourth industrial revolution’ possible might seem sleek, clean – almost immaterial – they are not.

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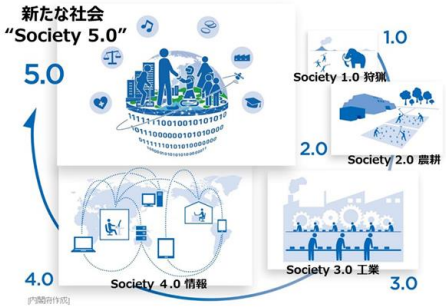
Towards agriculture 5.0, 6.0, 7.0?

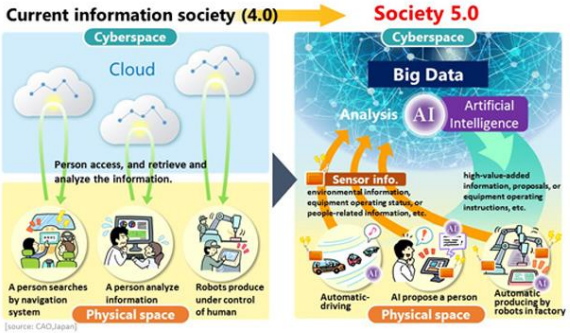
農業5.0、6.0、7.0に向けて？

Definition

To define the 7th agri-food industry, the 6th industry needs to be explained first. Conceptualized and developed as a government agricultural development policy in Korea and Japan, the 6th agri-food industry is basically combining agriculture (primary industry=1), food manufacturing (secondary industry=2), and the service industry (tertiary industry=3) involving sales, marketing, education, and tourism. This combination (1+2+3=6) allows local farmers to create new businesses and economic opportunities including manufacturing food product with their crops, running education or agri-tourism businesses using their farm products or facilities.

The 7th industry is basically adding cultural diversity value to the 6th industry. It is created when applying the Asian 6th industry concept to the US local farming community's effort to grow ethnic crops and produce ethnic foods.





- And what about mixing Agriculture 4.0 technologies with 'retro-innovation' (e.g., mixed systems, regenerative agriculture, etc.)?


One Earth
Volume 1, Issue 3, 22 November 2019, Pages 278-280
CellPress
Commentary
Agriculture 5.0: Reconciling Production with Planetary Health
Evan D.G. Fraser [1], Malcolm Campbell [2]

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3. Implications for organizing innovation イノベーションの組織づくりに向けた含蓄

What do future(s) of agriculture imply for AIS?

農業の未来がもたらす農業イノベーションシステム研究への示唆とは？

Global Food Security 24 (2020) 100347

Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs

Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways?

Laurens Klerkx[a,*], David Rose[b]

[a] Knowledge, Technology, and Innovation Group, Wageningen University, the Netherlands
[b] School of Agriculture, Policy and Development, University of Reading, United Kingdom

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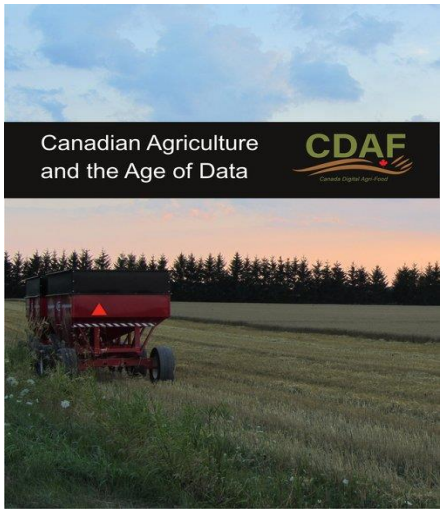
How do policy frameworks contemplate diversity in agriculture and food system futures?

政策枠組は、どのように農業の多様性と将来のフードシステムに取り組むのか？




sustainability

MDPI

Article

Translating Agroecology into Policy: The Case of France and the United Kingdom

Raquel Ajates Gonzalez [1,*], Jessica Thomas [2] and Marina Chang [3]

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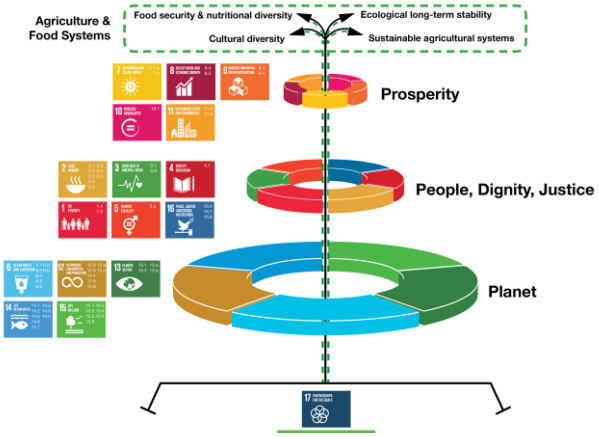
Contemplating diversity in AIS

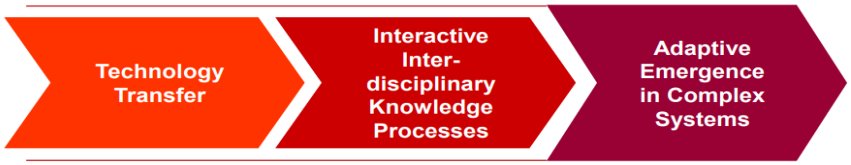
AISにおける多様性への考慮

- How agriculture is done and seen is changing and sector boundaries are blurring – multi-sector, country and technology interaction emerging
- Contemplating diversity of agricultural and food system futures, power and ethics



Can disrupting AIS offer some insights?

Towards Innovation 3.0



Innovation 3.0

- ✓ Based on the dynamics of complex social, economic and natural systems (cf. food systems: 'complex adaptive systems')
- ✓ Integrates and builds on Innovation 1.0 and 2.0
- ✓ Recognizes ethical dilemmas
- ✓ Combines technological and institutional innovation
- ✓ Deals explicitly with power and politics

John Ingram, 2016 based on Woodhill, 2012

Research Policy 47 (2018) 1554–1567

Contents lists available at ScienceDirect

Research Policy

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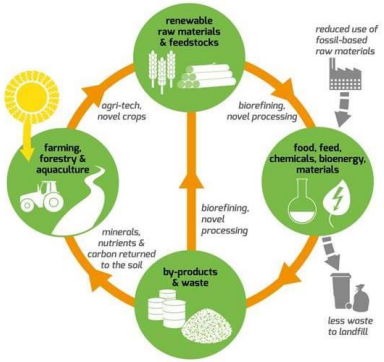
Three frames for innovation policy: R&D, systems of innovation and transformative change

Johan Schot*, W. Edward Steinmueller

Science Policy Research Unit (SPRU), University of Sussex, United States



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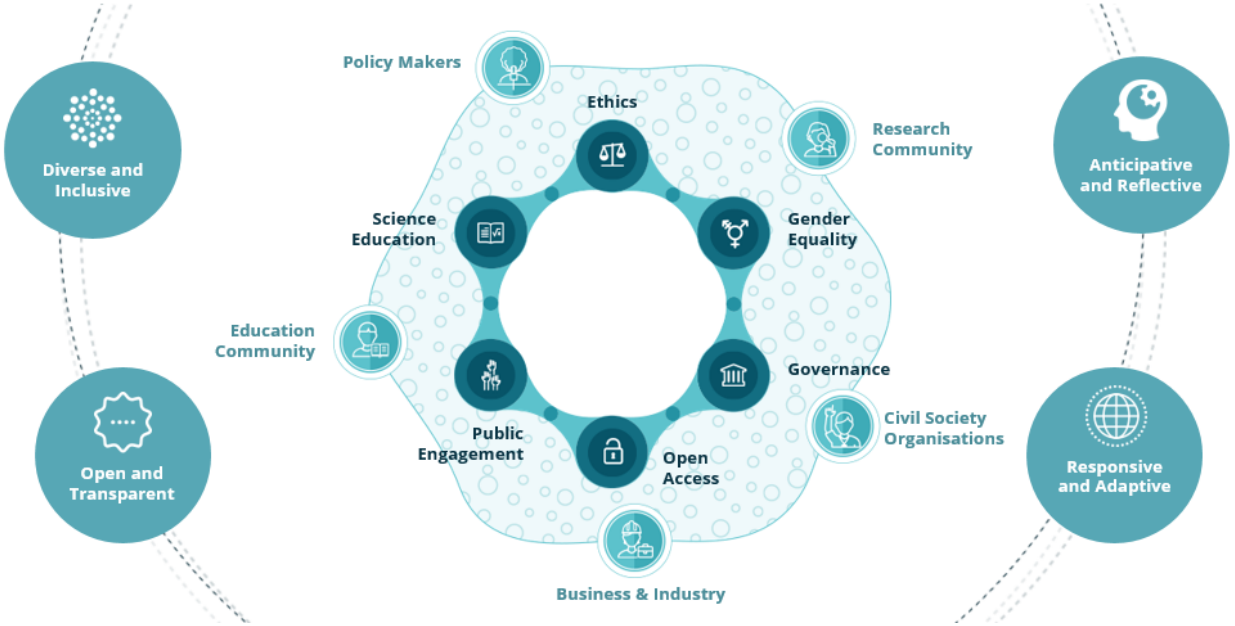
Contemplating responsible innovation in AIS

AISにおける責任あるイノベーションへの考慮

RRI is about: including all actors, and considering specific key issues and process dimensions



Source:

RRI Tools

UK Research and Innovation

Home About this system Release history

Developing 'Alternative Practices' for Responsible Research and Innovation in the UK and Japan

Lead Research Organisation: University of Edinburgh

Department Name: Science Technology & Innovation Studies

Chem-Bio Informatics Journal, Vol.18, pp.164-172 (2018)

Responsible innovation in molecular robotics in Japan

Go Yoshizawa[1*], Rinie van Est[2,3], Daisuke Yoshinaga[4], Mikihito Tanaka[4], Ryuma Shineha[5], Akihiko Konagaya[6]

Chapter 2

Case Studies for Responsible Innovation: Lessons from Fukushima

Yuko Fujigaki

Abstract This paper deals with the NPP (nuclear power plants) accidents in Fukushima in 2011 in the context of responsible innovation. Based on our book,

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How does this connect to some other challenges for the Japanese AIS?

いかに日本のAISが抱える課題と結びつけられるか？

McKinsey&Company

Pursuing such a program would require an incremental approach, for instance beginning with targeted pilot programs rather than attempting to implement new measures across several regions at once. More specifically, players in Japan's agricultural sector could designate specific pilot regions and enact decisively high-productivity best practices. As the pilot projects produce success stories, the practices can be spread to more regions, focusing on producers that are most willing to make needed changes in their processes.

A broader range of stakeholders, including universities and research institutions, should also be brought into the effort to achieve the greatest success

Agricultural improvements go beyond better cooperation among farmers, co-ops, and regulators. A broader range of stakeholders, including universities and research institutions, should also be brought into the effort to achieve the greatest success.

OECD

- Japan strengthened the engagement of farmers and other stakeholders in R&D planning, implementation and evaluation. Going forward, developing co-financing schemes for agricultural R&D investment with producers would allow the agricultural R&D system to be more demand driven. Co-financing schemes also
- Innovation in agriculture in agriculture today is more dependent on the technologies developed outside agriculture, such as genetics and digital technologies. This requires collaboration between public and private actors across sectors, and Japan needs to further strengthen the interconnections between AIS actors across sectors. While FKII and tax incentives for research collaboration are useful initiatives in this direction, Japan should remove the remaining impediments to cross-sectoral collaboration and further integrate agricultural R&D system with the economy wide innovation system.
- Attracting skilled labour to agriculture requires making agricultural industries more appealing and conducive to innovation and entrepreneurial opportunities. Skilled labour from different education backgrounds can also enrich the innovation process in the sector. More entry of private service providers, such as technical advisory services, would enhance skill supply in the sector.
- A mismatch between supply and demand of skills limits the capacity of the sector to develop and uptake innovation. Responding to the evolving need for skilled labour in agriculture requires retraining and regular adjustment of education programmes that reflect industry demand.
- Strengthening partnerships with the agricultural industry would allow agricultural colleges to expand their capacity and meet the labour-market needs more effectively, for example through more systematic participation of professional farms and agro-food industries in teaching and funding.

- Need for brokering interaction and partnership for co-design and co-innovation

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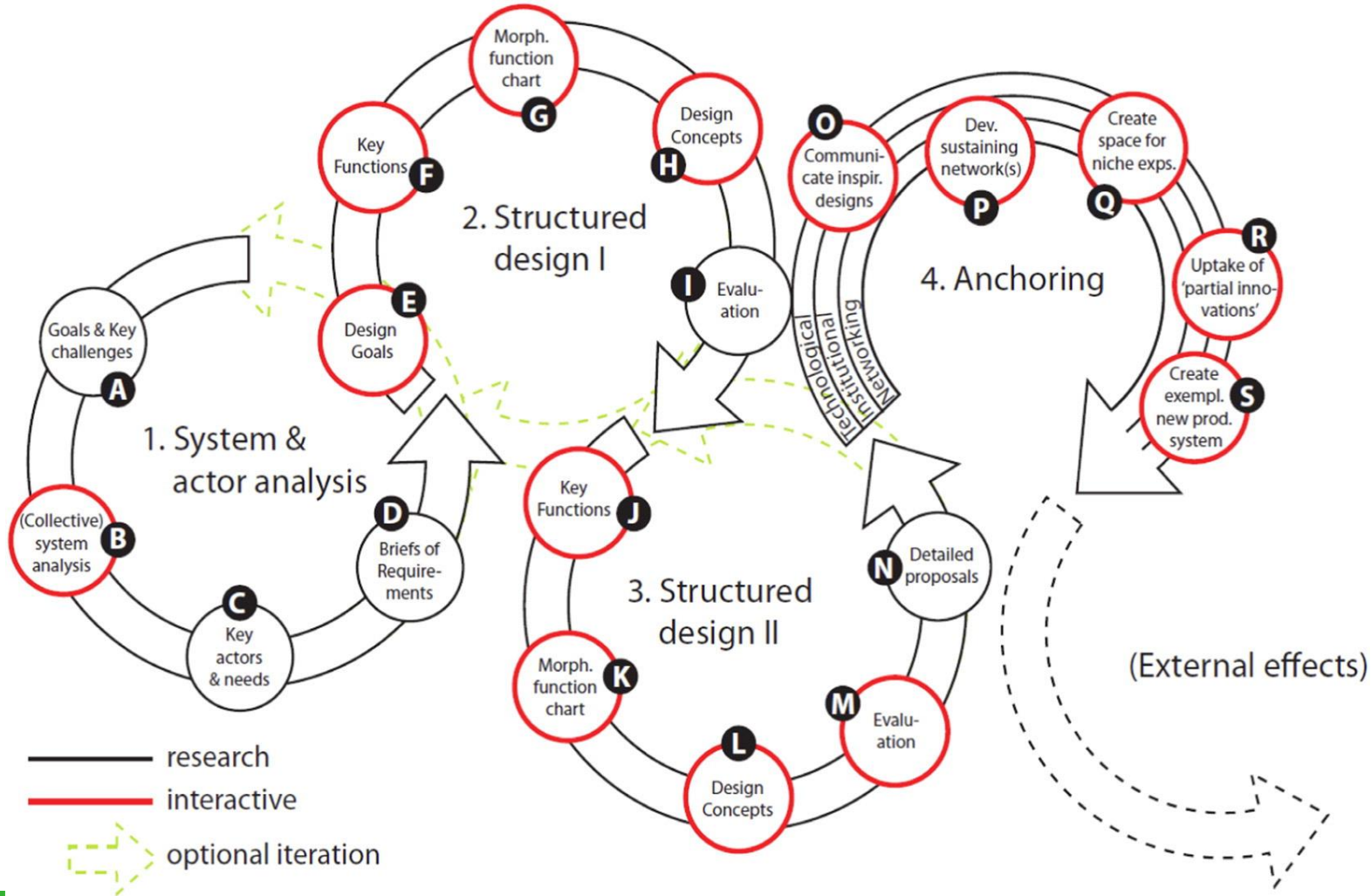
What can be done to enhance co-innovation? Some examples

共創型「コ・イノベーション」を促進するには、
どうすれば良いのか？いくつかの例

1. Reflexive interactive design: user driven transformation oriented design
2. Innovation brokers that foster co-innovation and transition networks and match demand and supply
3. Farmer/sector-driven research agenda setting

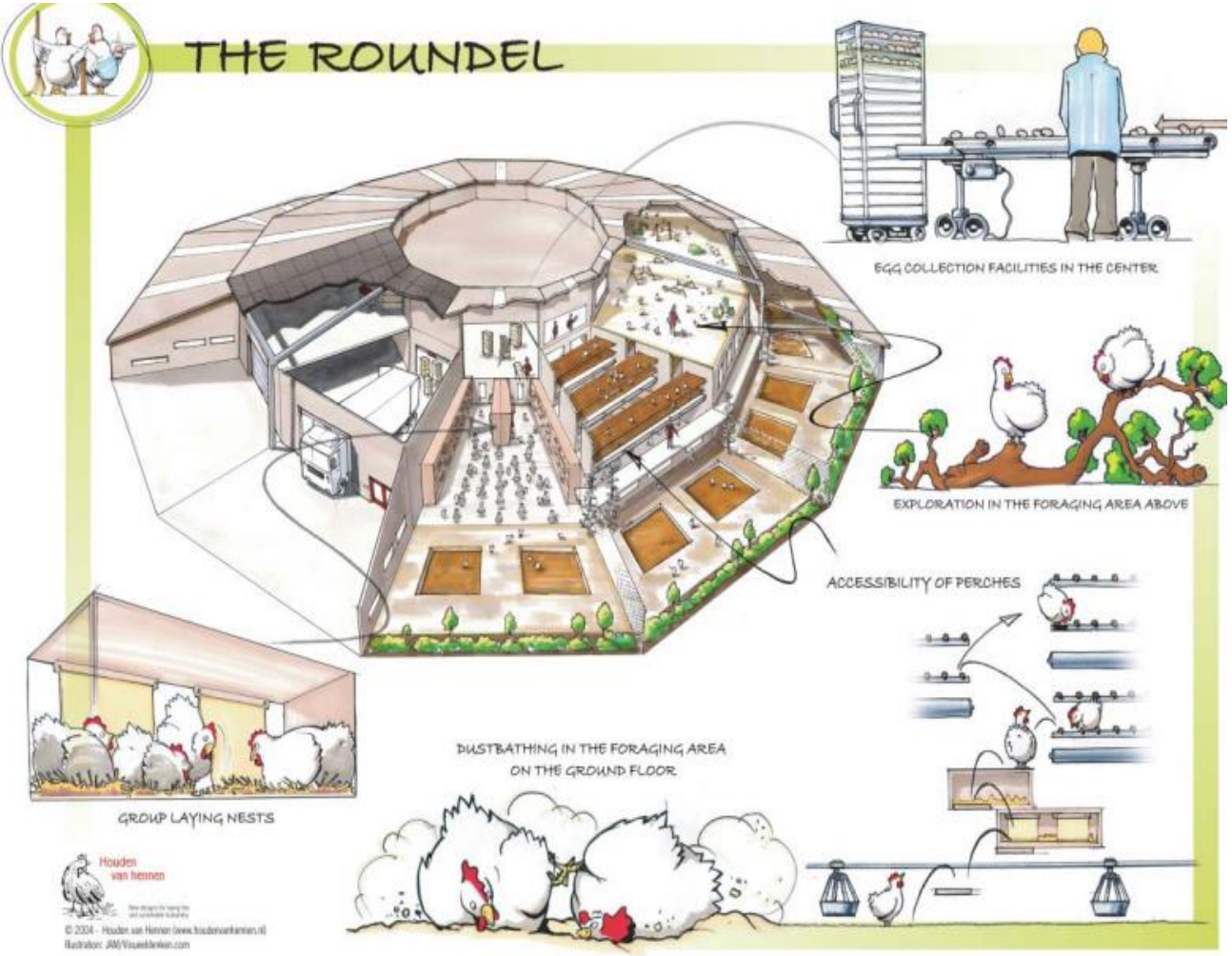
1. Reflexive interactive design of animal production systems

内省的・相互作用的な
畜産生産システムのデザイン



Source: Elzen and Bos, 2019

Laying hen sector 鶏卵産業



The basis for a comfortable chicken life is to be free of hunger and thirst.

How much space does a hen need?

A laying hen needs the following space to carry out her natural behaviours:

eating	446 cm^2
drinking	446 cm^2
scraping ground/foraging	799 cm^2
cleaning	1076 cm^2
dust bathing	1076 cm^2
egg laying	1055 cm^2
resting	538 cm^2

If we take into account the time that a hen spends on these behaviours, the extent to which hens 'synchronize' their behaviour (i.e. the extent to which they wish to carry out a behaviour at the same time) and the necessary space between animals for these behaviours, then we arrive at a husbandry system which supplies 2214 cm^2 per hen – or 4.5 hens per cm^2 living space.

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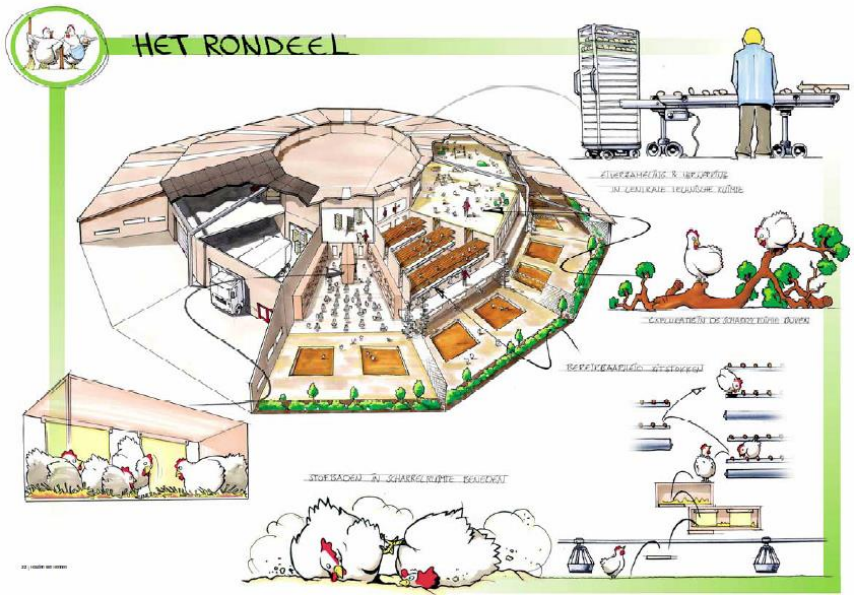
Is this fantasy? おとぎ話？



Yes, a fantasy come true
(in 7 years time)

Another example そのほかの例

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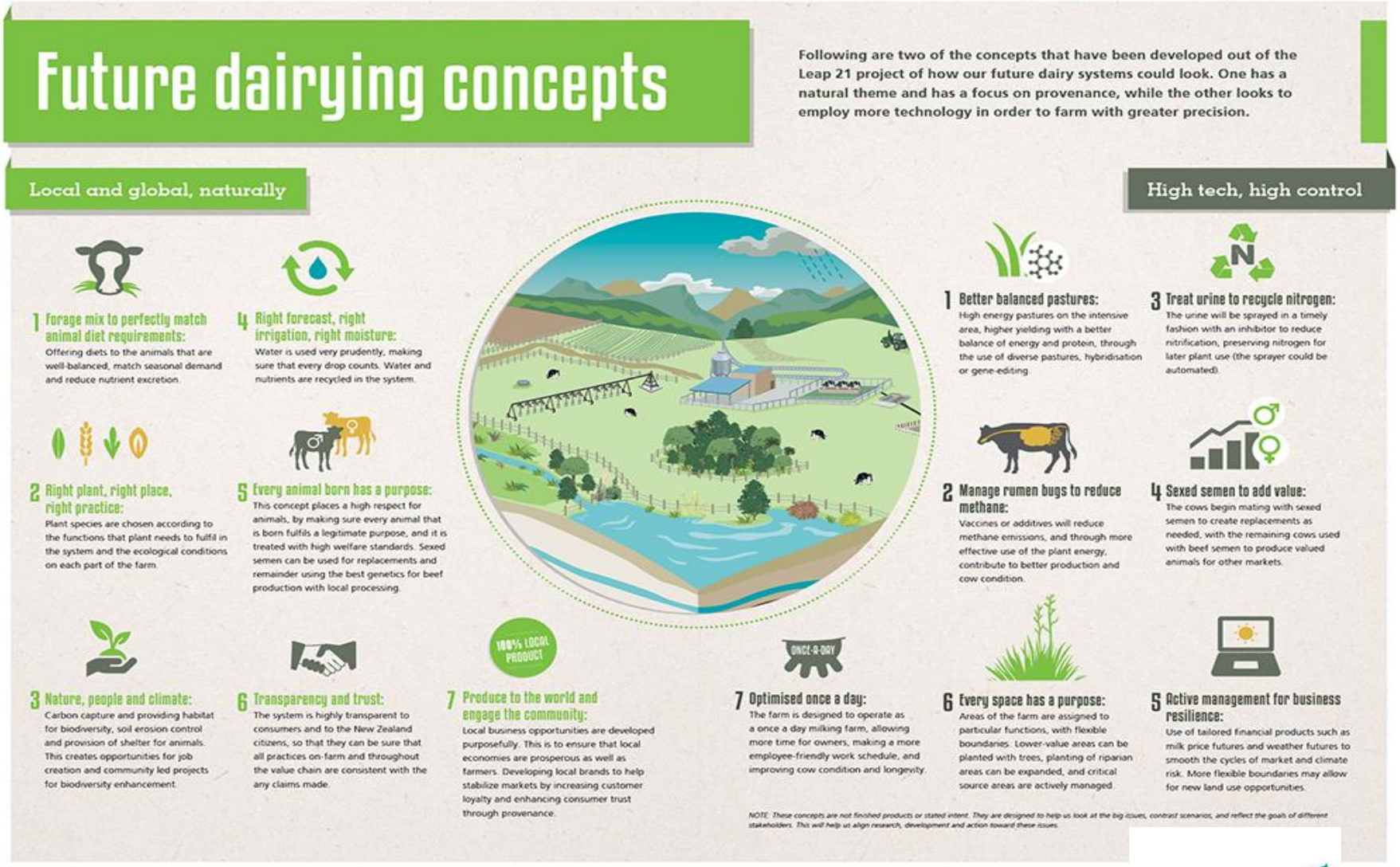
And another one... さらにもう一つの例…

New Zealand ニュージーランドの取組



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DairyNZ

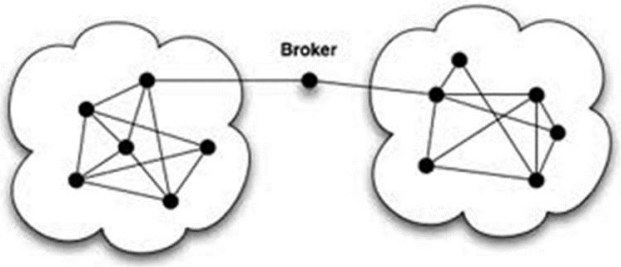
Reflections 考察

- Reflexive interactive design helps to make transformative food system ambitions tangible
- Design can be applied for different food system futures
- Designs are a starting point and it requires considerable follow-up activities and some determined champions of change
- Designs guide ensuing science investments and other interventions
- Requires mission oriented innovation policies to support the ‘niches’ and destabilize the ‘regimes’

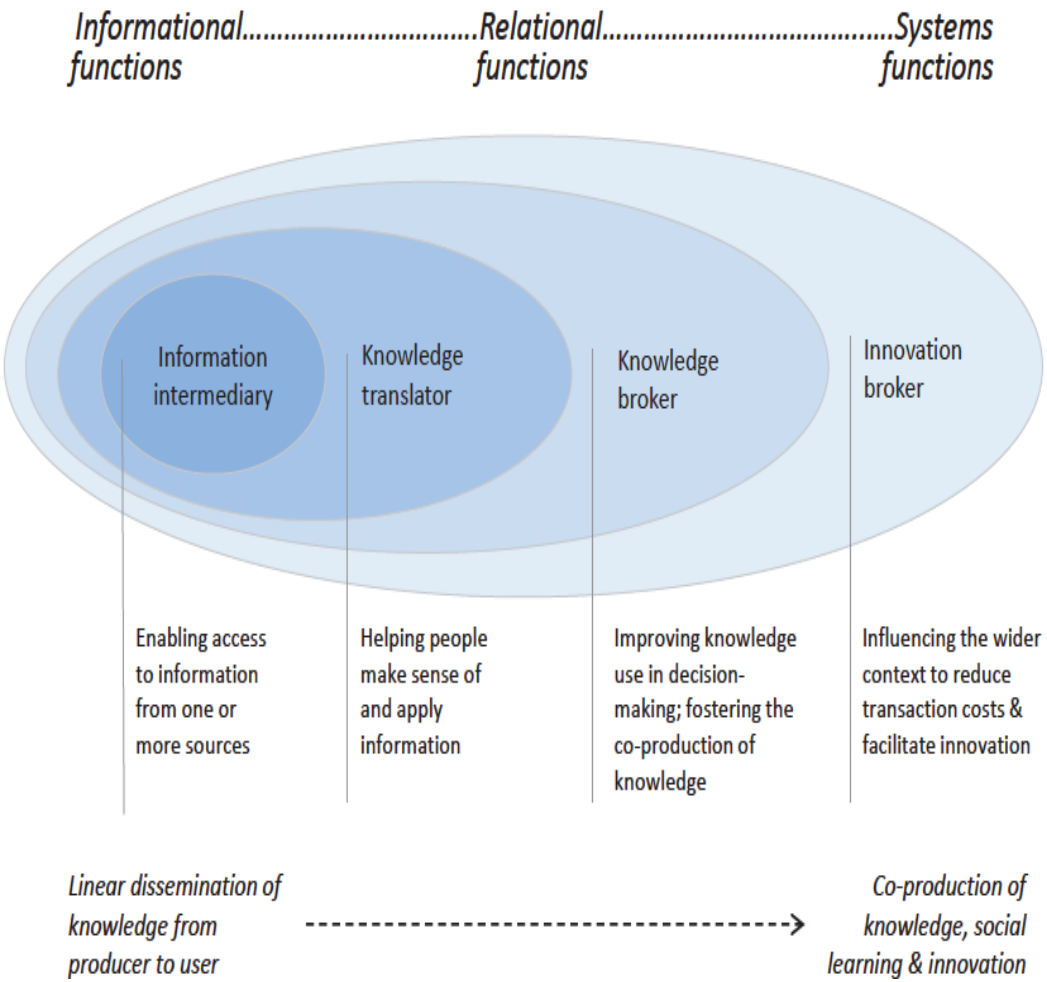
2. Innovation brokers that foster co-innovation networks and match demand and supply

コ・イノベーションのネットワークを促進し、需要と供給をマッチさせるイノベーションブローカー

- Several of these organizations have emerged since the 2000's in the Netherlands
- Some have been active for a while, some continue to exist
- Have also emerged elsewhere



Intermediation 仲介者



Source: Shaxson et al., 2012

Innovation broker functions

イノベーションブローカーの役割

- Connecting demand and supply in knowledge infrastructure and forging linkages for formation networks
- Main tasks:
  - Vision building and demand/supply articulation
  - network formation
  - innovation process management (i.e. network facilitation, reflexive monitoring)
- Contribute to realizing several 'innovation system functions'

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Innovation consultants

イノベーションコンサルタント

- Do ‘innovation’ quick scan/SWOT analysis
- Search and matchmake with possible cooperation partners
- If needed facilitate the collaboration

knowhouse
Fresh Innovations

crop eye
Dare to share

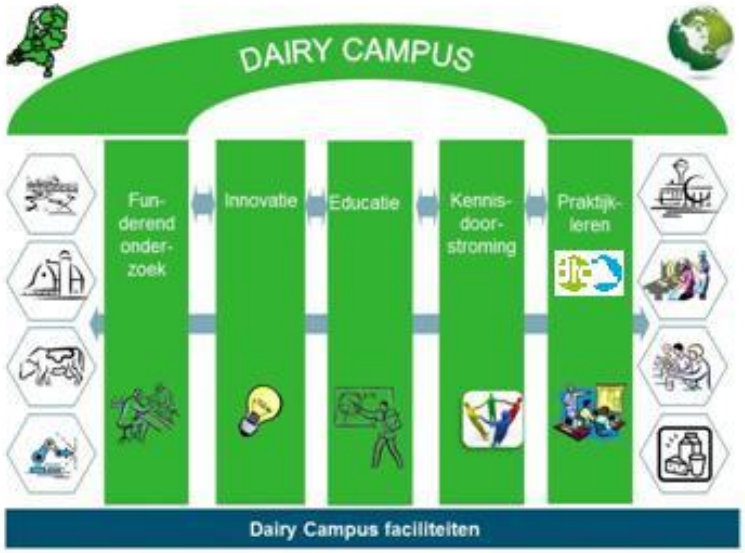
connecting agri&food

Agro Center
for Strategic Entrepreneurship

Stimuland

Innovation centres イノベーションセンター

DAIRY CAMPUS
Inspire to create



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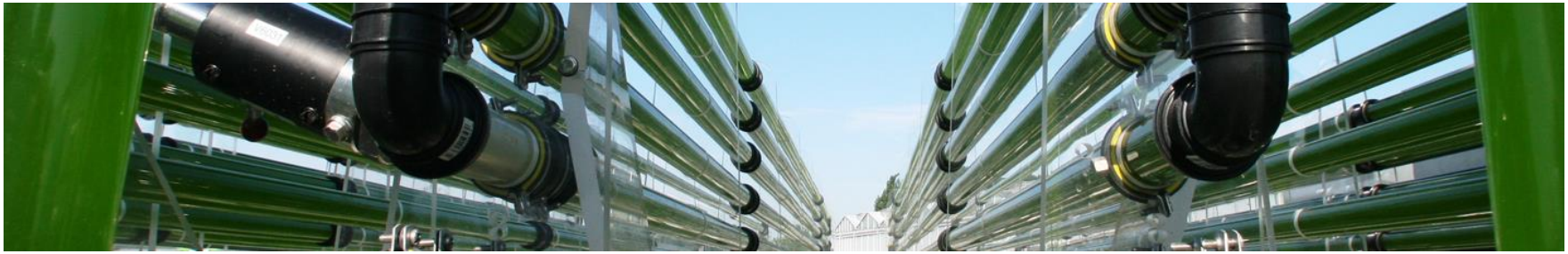
Innovation centres イノベーションセンター

Innovation centres イノベーションセンター

AlgaePARC™ is part of WAGENINGEN UR For quality of life



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Australia オーストラリアの取組

foodagility

How we work

An agile, design-led innovation hub.

At Food Agility CRC we don't just invest in research, we are an innovation hub that brokers teams, curates innovation projects and develops creative digital solutions for maximum industry impact.

We start with the challenges facing the agrifood industry. Then we bring together experts from across the agrifood, technology, research and government sectors to create new digital products and services that tackle those challenges in sometimes surprising ways.

Food Agility promotes data sharing within trusted networks and we are agile, involving end-users right from the start, market-testing digital solutions early and making improvements along the way.

We also keep a close eye on industry and market trends, collecting, analysing and presenting information about digital technology in the agrifood sector.

TransForum (2005-2010)

過去のプロジェクト"TransForum (2005-2010)"

- Short to medium-term focus (1-5 years)
- Portfolio of 30 projects
- Budget of 30 million euros (to be matched 50% with industry funds)
- Core vision 'metropolitan agriculture'
- Connecting to ongoing initiatives
- Support types:
  - Funding (for R&D)
  - Brokering
  - Facilitation

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SIGN: Innovation Foundation Horticulture

現行プロジェクト"SIGN：園芸分野のためのイノベーション基金"

- Long term vision: started in 2002 with vision for 2020
- Initial vision: greenhouse should produce energy
- Now much broader, e.g.:
  - Polydome (High Productive Polyculture Systems)
  - Work is Gaming: gamification of horticultural labor

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Courage 2025

“Courage 2025”プログラム

- Focus on the long term
- Free thinking to develop radical ideas
- Initiating experiments and pilot projects
- Making connections with uncommon partners (games developers, garden designers, etc.)
- Themes: energy & climate, closed cycles, animal health, entrepreneurship, nature & landscape

GRAS2.0
UNLOCK A NEW ECONOMY

GRASSA!
Meer waarde uit gras

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Cow garden “Cow garden”プロジェクト

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Topsector Agri & Food

トップセクターAgri & Foodプログラム

TKI Agri & Food

The Top Consortium for Knowledge and Innovation (TKI) coordinates the creation of the Knowledge and Innovation agenda of Top Sector Agri & Food, takes care of the research programme and advises the Top Team Agriculture & Food concerning arrangements with the Minister of Climate and Economic Affairs.

As far as the research programme is concerned, TKI Agri & Food supports innovation with a number of its own arrangements and offers co-financing for, for example, EU projects. So far this has resulted in around 500 research and innovation projects, large and small: TKI projects, MIT projects, NWO projects and EU projects that have all been supported financially by TKI Agri & Food.

An overview of all arrangements and options for co-financing of projects by TKI Agri & Food can be found on the Co-financing page. There you can find documents needed for the project justification and reporting.

Central themes TKI Agri & Food

- Consumer & Society
- Climate Neutral
- Healthy & Safe
- Circular
- Smart Technology

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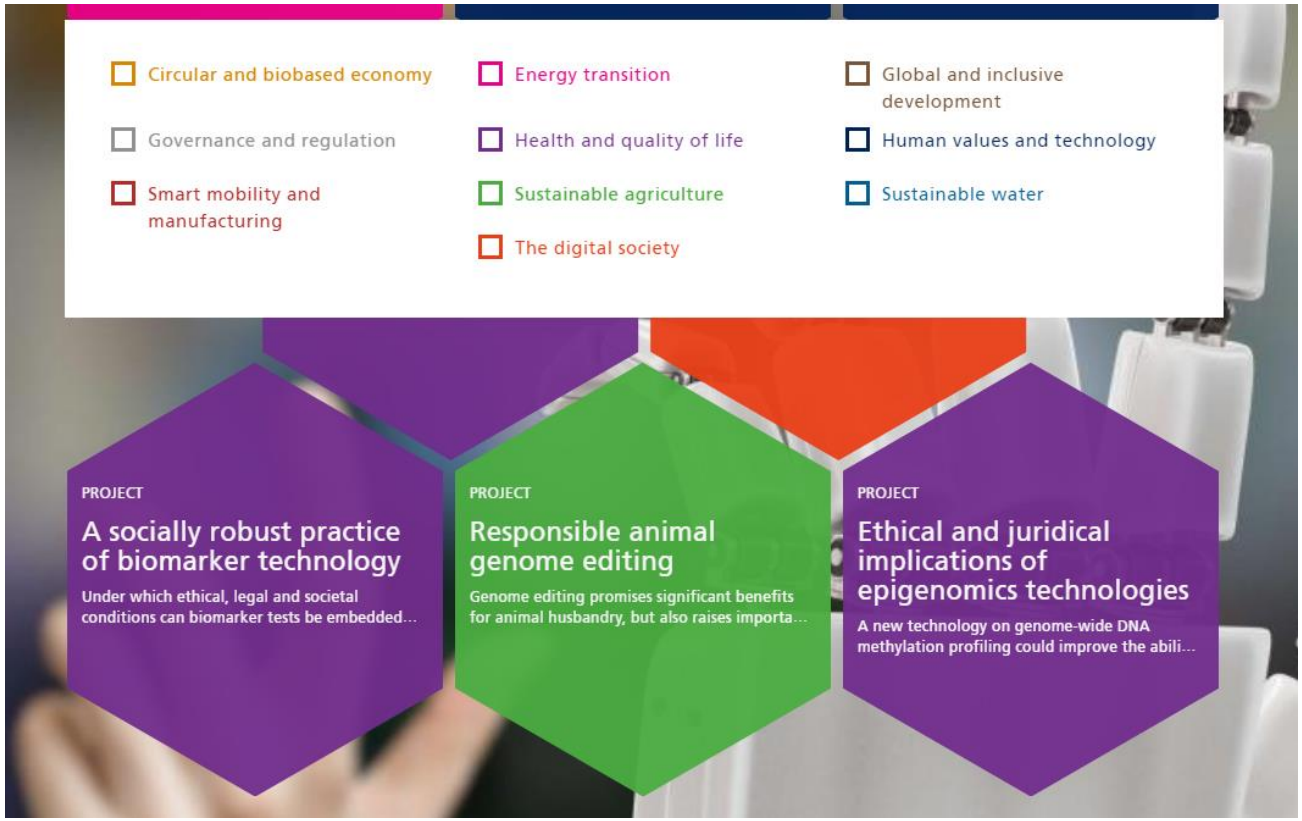
Platform for responsible innovation

責任あるイノベーションに向けたプラットフォーム

NWO MVI

PLATFORM FOR RESPONSIBLE INNOVATION

Platform voor Maatschappelijk verantwoord innoveren



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Reflections 考察

- Innovation broker helps to match demand and supply
- Innovation broker builds capacity for transdisciplinary research and innovation
- Innovation broker can help enact 'missions'
- But, innovation broker role is not an easy one:
  - Balancing demands from different parties - different accountabilities
  - Maintaining legitimacy in innovation/transition process in light of 'creative destruction' can be hard – dealing with issues of regime power
  - Innovation broker role is quite intangible, so low willingness-to-pay for this role
- Sometimes hard to navigate the diversity of programs

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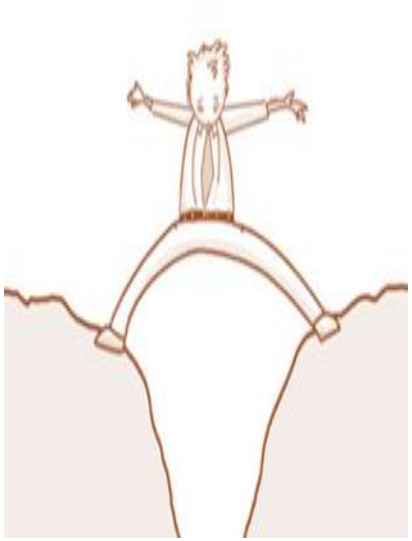
Implications for roles in AIS: extension

AISにおける普及の役割

- From information intermediary (science ->practice) to knowledge broker (between multiple bodies of knowledge)
- Given pluralism of current extension (or advisory) systems and complex queries of clients, need to consider 'networks of advisors' (brokered by innovation broker)
- Brokering between the science system and the extension/advisory and education system



Positioning innovation brokering in AIS

AISにおけるイノベーションブローカーの位置づけ

- Recognition of new/expanded roles for research and extension towards innovation brokering:
  - Other job perception & skill set needed (not only expert role)
  - Other evaluation criteria needed (not just publications)
  - Intangibility of much of the work
  - Role demarcation and ambiguities: who does what?

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Farmer-driven research agenda setting

農家主導型の研究アジェンダ

- Bioconnect: Research funder with co-innovation perspective
- Short to medium term focus: platforms for generating and executing R&D and innovation agendas for 1-5 years
- All value chain actors are present and have decision making authority and monitor progress
- Product or theme based workgroups

Bioconnect

HET KENNISNETWERK VOOR DE BIOLOGISCHE LANDBOUW EN VOEDING

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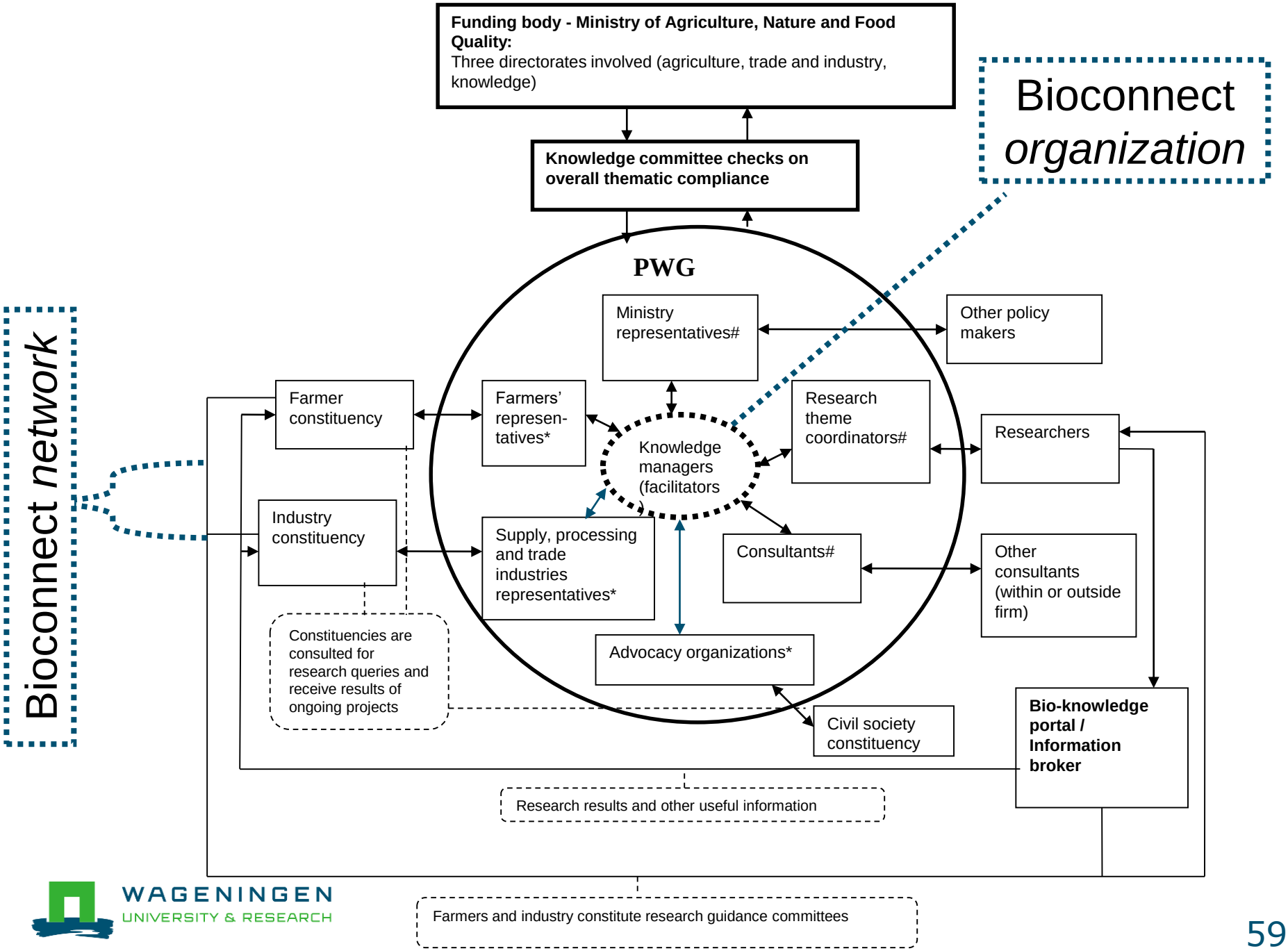

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From Bioconnect to Bionext

BioconnectからBionextへ

- Initially heavily subsidized (10 million euro per year)
- Handed over to the sector and merger with Biologica (sector organization)
- New organization: Bionext
- Innovation broker function funded 50% by Topsector

Bionext

Topsector Agri & Food

Reflections 考察

- Economic demand ≠ substantive demand
- Multiple demanders with different institutional backgrounds – demand articulation is dialogue and negotiation
- Network approach provides dialogue and ownership, but mutual understanding is not automatic
    - Facilitation and capacity building
    - Mutually understandable ‘ boundary objects’
- Could be broadened to a responsible innovation platform

Conclusion: suggestions for the Japanese AIS

結論：日本のAISに向けた提言

- Some suggestions:
  - Get a good overview of sorts of food systems, underlying paradigms and how they relate to Agriculture 4.0 technologies or other technologies (and their 'sub AIS')
  - Determine where different foods systems are in terms of transition and transformation (and how they link)
  - Determine what sorts of missions are important and what that implies of niche support and regime destabilization
  - Set-up targeted initiatives to stimulate co-design and co-innovation – connecting public and private interests and values – Japanese style as there is no universal recipe

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ありがとうございました
Arigatō gozaimashita!

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