

What agency is driving smart-breeding innovations?: Understanding the synergies and risks of the convergence and divergence innovation dynamics for plant-breeding and digital sectors

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INTRODUCTION

Smart-breeding is a concept to describe particular innovations that link plant-breeding practices and digital tools to respond to current agri-food challenges. For this, **smart-breeding are innovating by increasing the quality and quantity of data of plant-breeding processes to make better and quicker seeds, with increased quality and quantity of data** of the phenotype, genotype, and genotype by environment characteristics of plants (Khan et al., 2022; Singh et al., 2024; Xu et al., 2022). They intend to use digital tools to improve the plant breeding knowledge management processes, bundling plant-breeding and digital innovations such as genotype evaluation and selection of varieties through big data and artificial intelligence. In this way, they bundle innovations from the digital sector, the agri-food sector, and indirectly the environmental sectors into one. They are a so-called **“bundle of innovations”** (Barrett et al., 2022), that link these two sectors by bundling digital innovations to increase plant-breeding capacities for resilience of agri-food systems.

Despite the **high potential technological capabilities** that smart-breeding innovations may bring to improve crops (Xu et al., 2022), **this bundle of innovations may also lead to potential negative effects** (Galaz et al., 2021; Klerkx et al., 2019; Ryan, 2023). They include the cost of big data management over other agri-food priorities (Germain, 2018), and social concerns including employment, trust, and ownership linked to plant-breeding standards and a potentially new data management (collection, usage, storage, and diffusion of data). There are also environmental concerns about the increased resources required for big data and artificial intelligence AI, and the potential effects of the improved seeds in different environments (Klerkx et al., 2019; Potts et al., 2023; Qaim, 2020; Ryan, 2023). For instance, a drought-resilient seed may result in other local problems such as reduced productivity or nutritional capacity (Montwé et al., 2015), that can only be analyzed case-by-case basis (Qaim, 2020).

Therefore, the **convergent and divergent directions** of the agents of the innovation, may **increase or reduce the risk of the innovation**. Thus, in this research we aim to understand the opportunities and challenges of bundling these sectors together to comprehend potential effects and trade-offs of smart-breeding innovations that result from the agents driving the innovations.

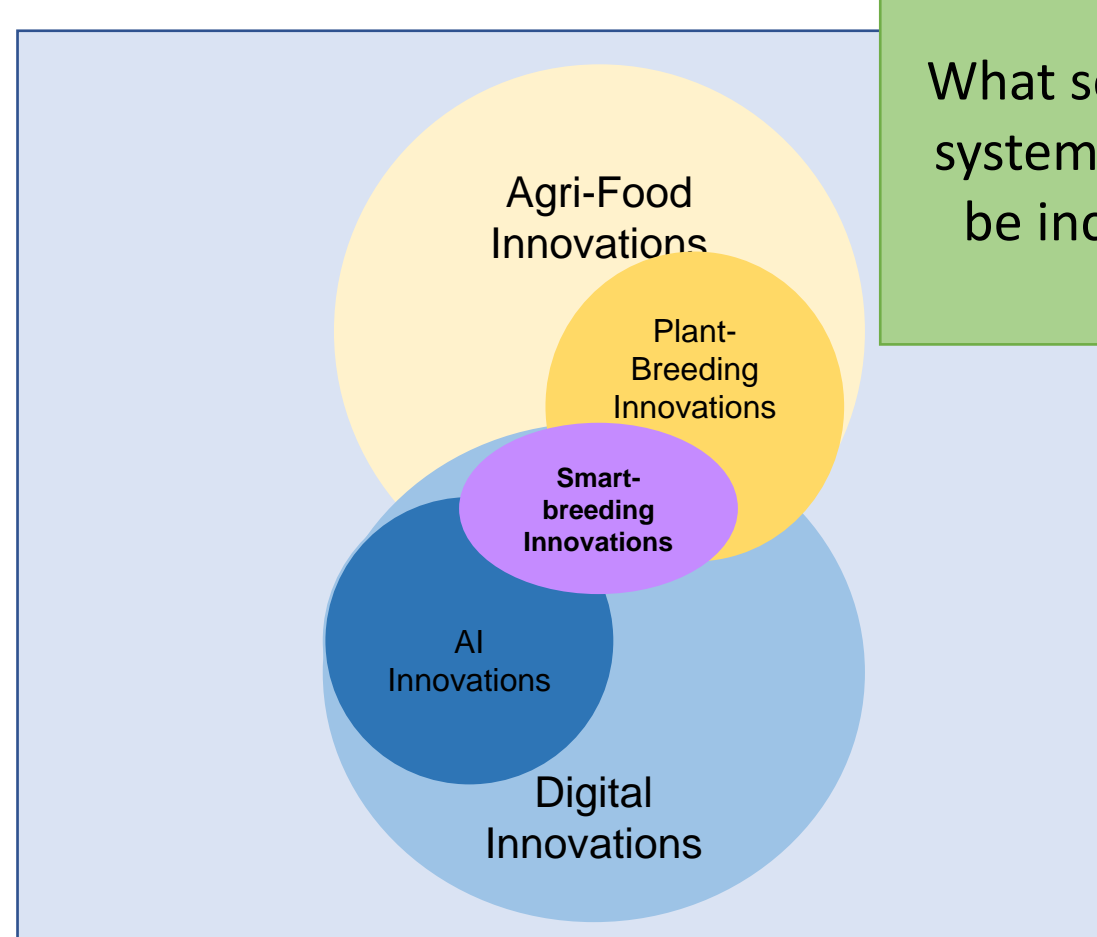
METHODS

A **mixed-method methodology** will be used to understand the extent to which the **convergence and divergence agency dynamics** of stakeholders drive smart-breeding innovations. For this, a **literature review and participatory methods** such **semi-structured interviews** will be done, based on innovation studies, transition studies including mission-oriented innovation systems frameworks to understand how both plant-breeding and digital sectors converge and diverge, and the opportunities and challenges of these dynamics.

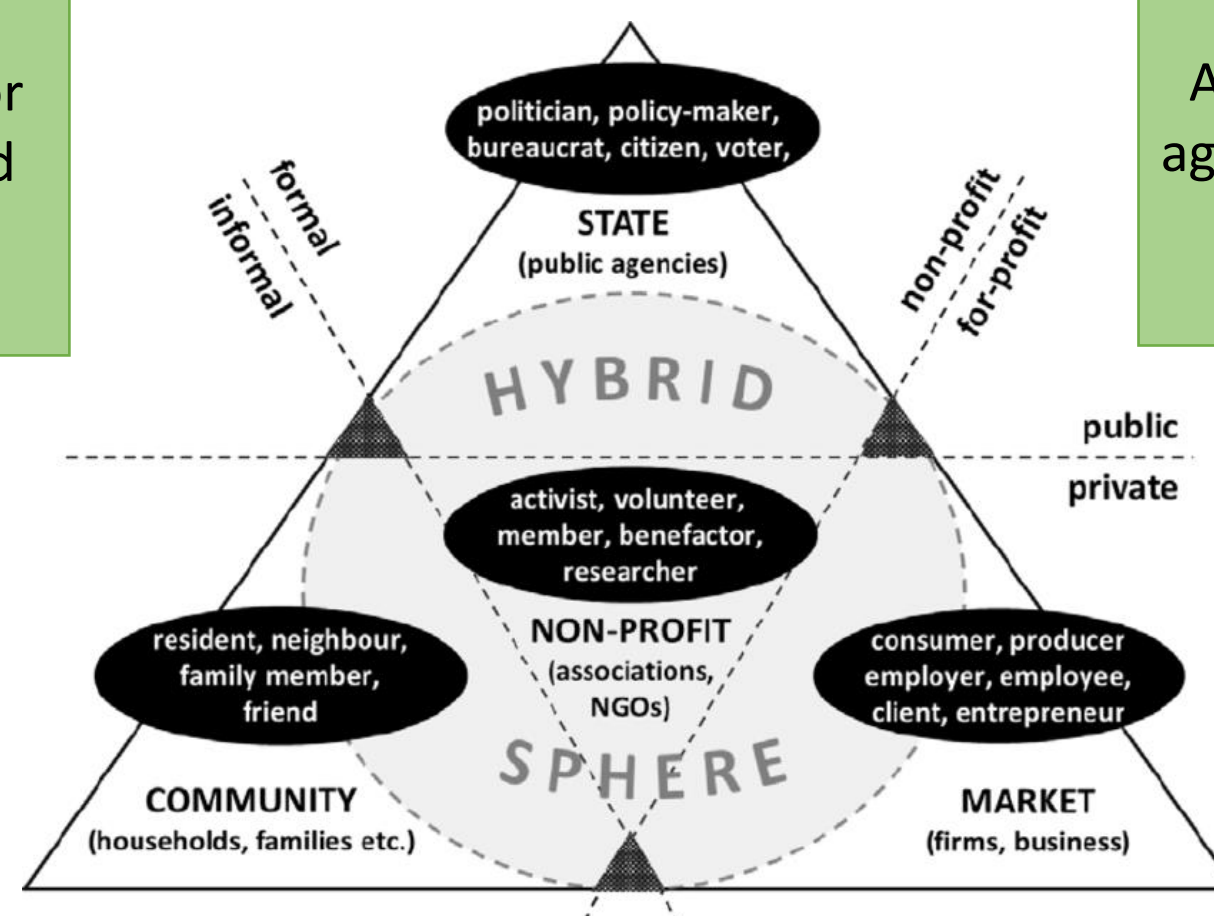
There will be four research questions for this:

- What are the **human and non-human agents** in smart-breeding innovations?
- What are the **cross-sectoral activities and interactions** between human and non-human agents as part of smart-breeding innovation dynamics?
- What **results, outcomes, and impact** are expected from smart-breeding innovations?
- How do human and non-human agents constitute a **mission-oriented innovation system for smart-breeding**?

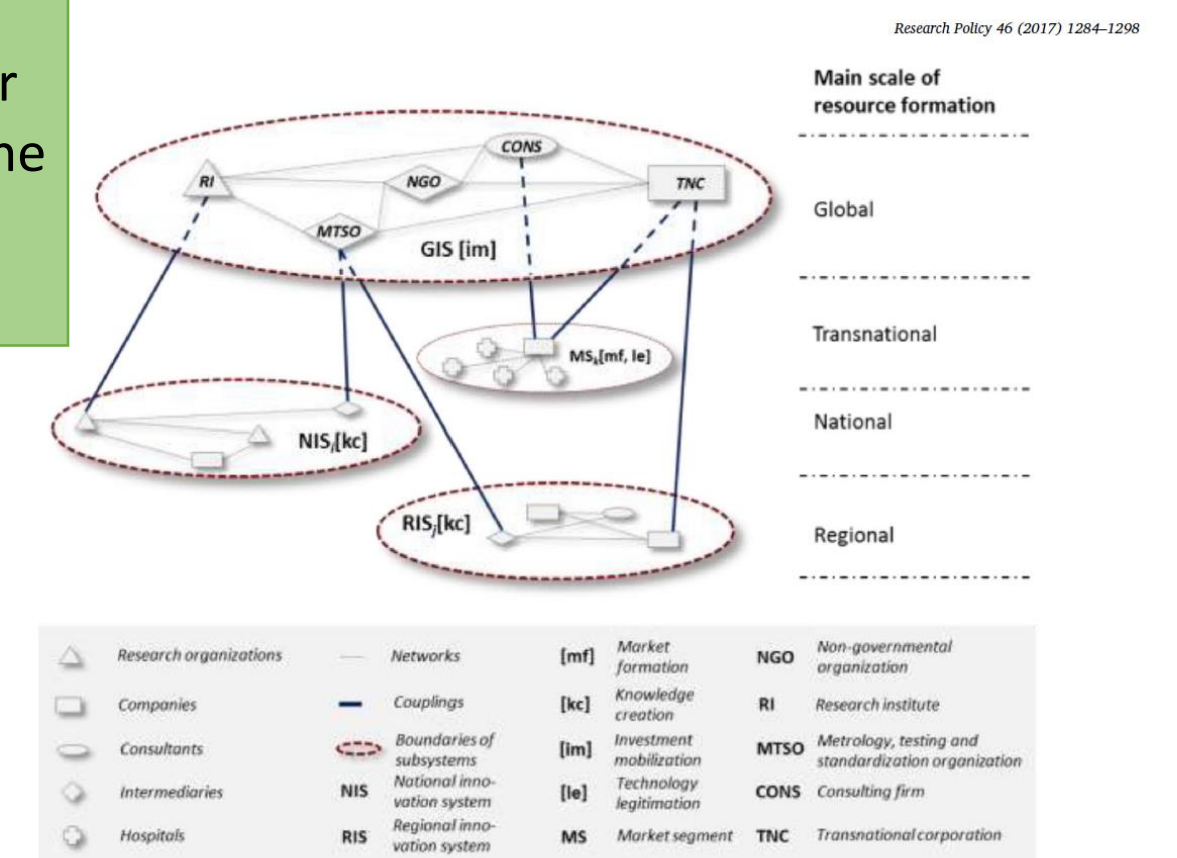
RESULTS



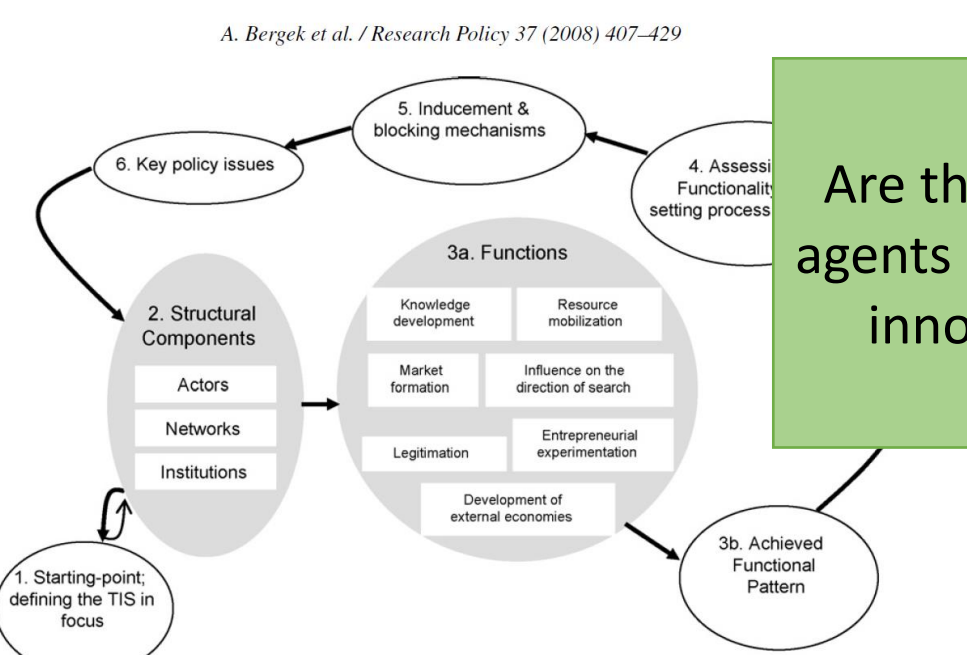
What sectors are linked in smart-breeding innovations? Source: Own Creation



1) Who are part of Smart-breeding innovations? Multiactor Perspective to characterize relevant stakeholders for a transition (Avelino and Wittmayer, 2016)



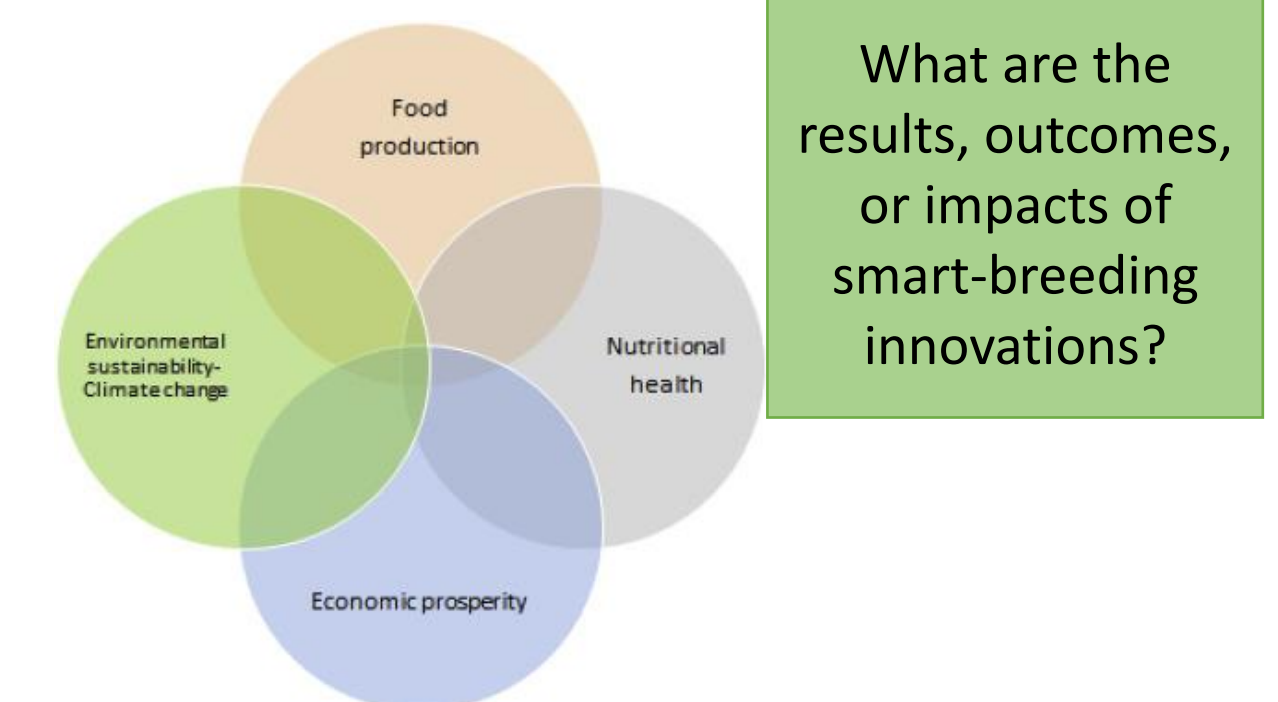
1) Who are part of smart-breeding innovations? Global Innovation Systems perspective analyzing stakeholders at multiple levels: actors, networks, institutions (Binz and Truffer, 2017)



2) What activities and interactions are done between agents as part of the innovation? (Bergek et al., 2008)



2) What activities and interactions are done between agents to support the normalization of the innovation? (Geels, 2011)



3) What are the results, outcomes, or impacts of stakeholder dynamics of smart-breeding innovations? (Balié, 2020)

CONCLUSION

- Smart-breeding innovations are a niche innovation bringing complex stakeholders from different sectors to increase the quality and quantity of data to improve breeding processes with digital tools.
- The stakeholders that might be relevant for smart-breeding innovation development include actors, networks and institutions from state, community, market and non-profits from different industrial sectors with technical breeding and digital expertise in agri-food innovations. However, there may be other relevant actors to increase its impact and reduce its risk which have not yet been accounted for.
- There are convergent and divergent activities and roles of the multiple stakeholders that are working in the innovation itself can include: knowledge creation and diffusion, market formation, knowledge development, resource mobilization, influence on the direction of search, entrepreneurial experimentation, legitimation, and development of externality benefits. At the same time, other innovators in the system also have to innovate with them, in their practices in policy, user and market, sociocultural, technologies, and scientific practices.
- Smart-breeding innovation results, outcomes, and impact have trade-offs and synergies. The understanding of the agency convergence and divergence dynamics may bring light to potential opportunities and challenges of the innovation.
- The understanding of how agents converge and diverge through smart-breeding development processes may be able to show potential and alternative smart-breeding innovation pathways, depending on the stakeholders selected and involved, and the interactions between them. The results of this research may be relevant for those stakeholders that will be part of the preparation, implementation, diffusion and evaluation of smart-breeding innovations, to understand the alternative opportunities and risks of their collaboration.