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EVALUATION OF TRANSFORMATIONAL R&I POLICY: LESSONS LEARNED BASED ON A RETROSPECTIVE REVIEW OF FOOD SYSTEMS R&I INVESTMENT IN THE EU

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ABSTRACT

This paper shares our experience of developing an EU-level baseline for research and innovation (R&I) in food systems, in support of the European Commission's transformation agenda, with specific reference to the Food 2030 initiative. Food 2030 relates to the EU's mission-oriented approach to R&I, viewing it within the context of a dynamic food system with multiple dependencies and many different actors. This approach aligns with a growing recognition that, in order to achieve transformational change, the interactions and interdependencies of all components within a given system and its relationship to other systems must be considered.

In a transformative R&I system, innovation itself is no longer the end-goal but is viewed as an enabler to solve societal and environmental challenges (the end-objective). Linking such broader outcomes back to specific R&I inputs is not a straightforward endeavour. Furthermore, the inter- and transdisciplinary nature of a systems approach, as well as the nature of systems thinking itself, make it hard to define evaluative boundaries. Traditional public sector approaches to supporting R&I do not align well with such an approach, with implications for evaluating R&I policy.

The paper focuses specifically on the novel aspects of the EU's approach to framing food systems R&I and the evaluation challenges this presents, as well as how we have worked to mitigate these.

INTRODUCTION

Ensuring and creating a sustainable, climate-friendly Union is seen as a priority in order to future-proof the EU. In 2019, the Von der Leyen Commission introduced the European Green Deal – a set of policies to improve the sustainability of the European economy and ultimately achieve climate neutrality by 2050. A number of key policy initiatives further support the Green Deal's overall objectives. In relation to food, the Farm to Fork strategy aims to transform European food systems to become the global standard in sustainability while striving to supply healthy, safe, equitable, and environmentally friendly food.

Climate change and over-exploitation of planetary resources have been identified as key risks by scientists, and a particular threat to the stability of the global food system. Intensive farming practices have been linked to significant biodiversity loss and a decrease in overall soil quality, leading to reduced agricultural productivity and a reduction in the nutritional quality of food. Combined with a growing population, increased pressure on natural resources (including both land and water) and the growing prevalence of nutrient-poor diets, current production and consumption systems represent a serious threat to food and nutrition security (FNS). In this article, we therefore view food as a complex or "wicked" problem. As conceptualised by Rittel and Webber in 1973, a wicked problem is multifaceted, with no definite boundaries, and thus results in multiple different perspectives, including sometimes contradictory views regarding the main challenges, priorities and required solutions.

Research and Innovation (R&I) is considered a key tool in addressing wicked problems (including FNS). However, instead of addressing a market failure (fixing under-investment) or a systems failure (focusing on knowledge transfer and network creation), food systems R&I can be described as relating to a transformation failure. As defined by Dinges, Meyer and Brodnik (2020), the transformation-failure rationale links R&I policy to contemporary social and environmental challenges such as the Sustainable Development Goals and calls for transformative change. A transformative R&I policy response involves public and private sector actors at all levels and in all relevant sectors.

New technologies and new innovative processes are needed at all levels and in all sectors of the food value chain (including food production, processing, distribution, logistics, retail, recycling etc.) to enable such a transformation of food systems. However, a 2018 report by the SCAR Food Working Groups into R&I on food systems by European Member States identified a lack of coherence in R&I strategies and approaches to FNS at EU level and between EU Member States. The report showed that R&I activity tended to address compartmentalised elements of food supply chains rather than taking a systemic approach. Additionally, at the European level, support for food-systems R&I was distributed between different Commission services, programmes, and funding instruments.

The EU's Food 2030 policy has been designed to address this fragmentation, acting as a bridge between the European Green Deal, the Farm to Fork Strategy and the EU Framework Programmes. Food 2030 is intended to create a coherent and comprehensive approach to EU-

funded R&I on food systems transformation. It provides a roadmap demonstrating how R&I can be leveraged to ensure the long-term resilience and sustainability of the European food system in order to ensure affordable, nutritious and safe food for all European citizens within healthy planetary boundaries. It also outlines an approach for EU-funded R&I for sustainable, healthy and inclusive food to be deployed via Horizon Europe instruments, including Missions (for example the "A Soil Deal for Europe" and "Adaptation to Climate Change" missions), partnerships, and calls for proposals within Cluster 6 "Food, Bioeconomy, Natural Resources, Agriculture and Environment".

Food 2030 supports an interdisciplinary approach to food systems R&I, with the aim of strengthening policy coherence, leveraging funding and investment, supporting the development of a wide variety of innovations – from disruptive technologies to new governance processes and increasing market take-up of food products, tools and approaches and business models required to support the transition to a more sustainable and resilient EU food system. The policy framework encompasses the entire food system, taking in the whole value chain from production, packaging, transport, food environment, consumption, to waste management and health. Food 2030 identifies four priority areas for food systems R&I and ten "pathways for action", designed to provide a framework for the future-proofing of food systems through R&I action and investment (European Commission, 2020).

In late 2020, Ipsos (whose study team included the authors of this paper) was commissioned by DG RTD to carry out a comparative study related to the Research and Innovation (R&I) investment level in food systems in Europe (referred to as 'our study' throughout this paper). Our study was intended to develop a detailed understanding of the current state of play of investments in food systems R&I, both at the national and EU level, and to provide indications on the optimal level of investment that would be required to achieve the priorities identified in the future European Green Deal and Farm to Fork strategy for sustainable food systems. It mapped existing levels of public and private sector R&I investment (covering the period 2007–2020) at national and EU level against the specific priorities and pathways described within the Food 2030 strategy. By analysing historic trends for different actors within the food system, we aimed to build a preliminary view of R&I within the EU food system and identify potential future areas of intervention.

Our study involved the creation of a retrospective baseline, mapping historic levels of R&I expenditure from 2007 to 2020 against the priorities, pathways and sectors identified in the Food 2030 policy. As Food 2030 was developed after the funding being reviewed was allocated, this required an effective retrofitting of data into the specified categories. This, combined with the challenges associated with the transformative nature of the Food 2030 agenda and the wicked problem it was intended to address, led to a number of conceptual and practical challenges, which we will outline in this paper. These include considerations of how to define the scope of a systems-based approach, how to combine traditional and innovative methodological approaches to measure systemic R&I, and the implications of a systems-based approach for national and EU funding and innovation agencies.

IMPLICATIONS FOR RESEARCH AND EVALUATION: CONCEPTUAL ISSUES OF SYSTEMS TRANSFORMATION

The novel approach taken in the formulation of Food 2030 as a transformative R&I policy framework meant that the challenges associated with evaluating systems transformation applied to our study as well. This section outlines the differentiating factors of R&I policy to enable systems transformation and introduces the conceptual issues this causes for research and evaluation.

There is a growing body of literature (Zhang et al., 2018; Gill et al., 2018; Kok et al., 2019, Den Boer et al., 2021) supporting the use of a systems focus to address societal challenges linked to the global food system. R&I is considered to be a contributor to and catalyst for systems transformation. Recognising the complexity of the systems it tries to foster, as well as considering the R&I landscapes' own complexity, approaches to R&I are increasingly required to take into account the dynamism and interdependent nature of the systems they are interacting with. The systems approach is therefore more and more being applied to R&I policy. Den Boer et al. (2021) stress this notion when arguing that the complexity of food systems (implicitly applicable to systems transformation generally) requires R&I policy approaches to be both *interdisciplinary* as well as *transdisciplinary*.

Systems are interdisciplinary by nature, and beyond simply fostering multidisciplinary research, a holistic view encompassing all aspects of the system is required in order to fully understand it and thus drive change while delivering multiple as well as co-benefits and mitigating trade-offs. As defined by Den Boer et al., (2021), transdisciplinary research approaches mean that different communities of knowledge and different stakeholders (including policy makers, industry, society, SMEs) come together to "form a 'real-world laboratory' for experimentation". Complex systems mapping in cooperation with different actors is needed, as systemic transformation requires not just knowledge generation, but also appropriate implementation based on a nuanced understanding of research outputs.

A first conceptual issue which we identified when seeking to evaluate transformative R&I relates to the **lack of a measurable end objective** against which to assess impacts. Transformative R&I policy does not pursue innovation itself as the end-goal, as traditional R&I does, but rather views it as an enabler to solve societal and environmental challenges (the policy's actual objective). This means that traditional indicators such as patents, publications or market-readiness cannot in and of themselves provide evidence that R&I is indeed achieving the societal transformations for which it is being deployed. Furthermore, such indicators do not capture outcomes generated by innovation (or knowledge) systems that go beyond straightforward results. Innovation (or knowledge) systems also communicate and disseminate innovation and research outcomes to facilitate and incentive further change in the system, as well as to allow for feedback loops and evolution of knowledge (Gardeazabal et al., 2021). A shift in focus towards outcomes of systemic change (across all its levels) is therefore required (Molas-Gallart et al., 2020).

Our research addressed this issue **by using the priorities and pathways laid out in the Food 2030 policy as a common point of ref-**

erence against which to map both EU and national level investments. The pathways to action, in particular, represent the areas where the EU believes additional action and investment is required in order to achieve the high-level policy goals laid out in the EU Green Deal and the Farm to Fork Strategy. Namely, they are: 'Alternative Proteins and Dietary Shift', 'Urban Food Systems Transformation', 'The Food Safety Systems of the Future', 'The Microbiome World', 'Healthy, Sustainable and Personalised Nutrition', 'Food Waste and Resource Efficiency', 'Food Systems Africa', 'Food from the Ocean and Freshwater Sources', 'Governance and Systems Change', and 'Food Systems and Data'. By mapping R&I projects against these pathways, levels of expenditure become a proxy for innovative activity, allowing us to build up a map of hotspots, duplications, and potential gaps in achieving the EU's policy goals.

As found in our study, food-systems related R&I accounted for 3.9% of EU R&I expenditure under FP7 and Horizon 2020, amounting to **EUR 4.84 billion** in total. The share of food-systems related R&I increased sharply under Horizon 2020, reflecting the stronger mission-oriented approach taken through the newly introduced societal challenges. Over 50% of food systems funding provided through FP7 and H2020 was mapped against only four of the ten Food 2030 pathways (accounting for between EUR 550 and EUR 750 million per pathway): "Food Waste and Resource Efficiency", "Food Systems and Data", "The Food Safety System of the Future", and "Food from the Oceans and Freshwater Resources".

This contrasts with the pathways "Urban Food Systems Transformation", "Food Systems Africa", "Alternative Proteins and Dietary Shift" and "The Microbiome World", which each received between 3% and 4% (between EUR 135 and 175 million) of all relevant funding on food systems under FP7 and Horizon 2020. Furthermore, approximately 19% of projects did not fit within any of the definitions assigned to the ten Food 2030 pathways, although they aligned with the broader Food 2030 priorities.

Figure 1: EU public food-system related R&I funding (EUR million, %), per Food 2030 pathway, under FP7 and Horizon 2020 separately
Source: Ipsos analysis of CORDIS data, Inner circle = Horizon 2020 Alignment with the FOOD 2030 Pathways; outer circle = FP7

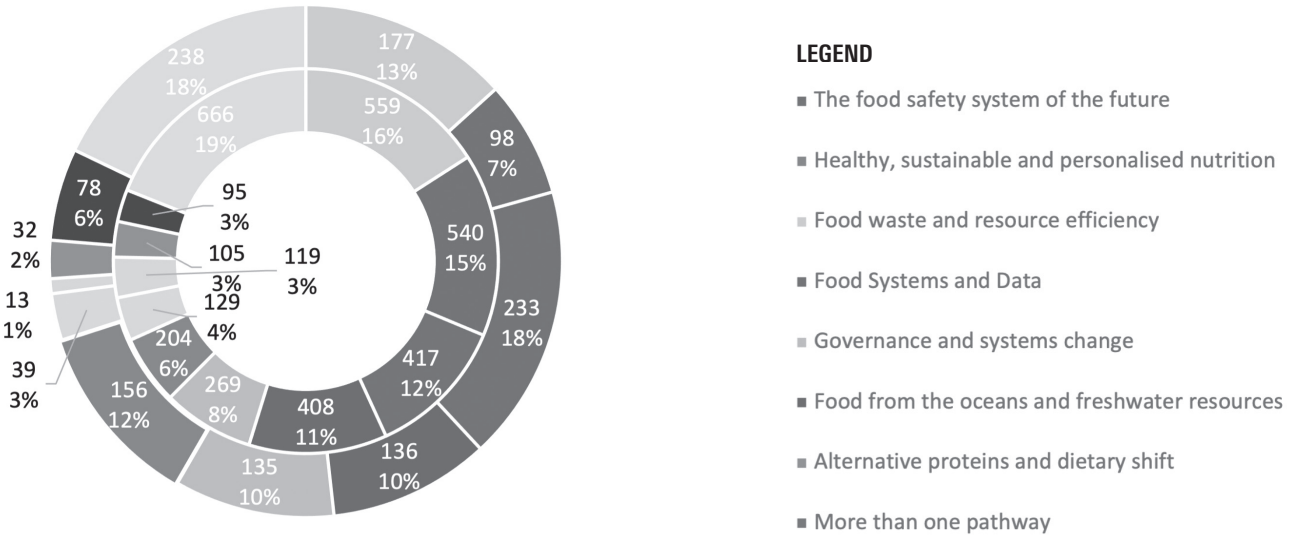
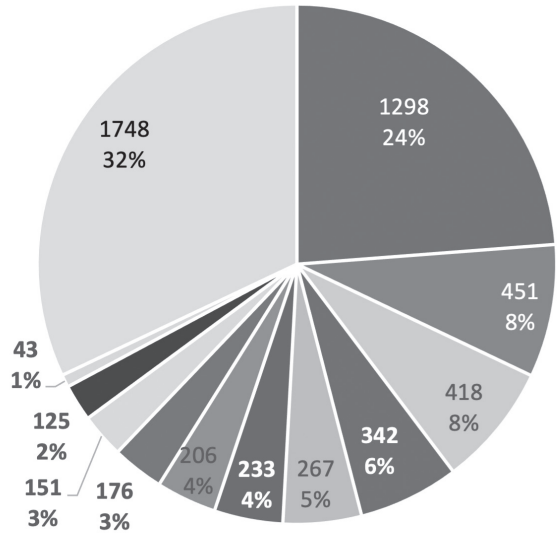


Figure 2: National food R&I expenditure by Food 2030 pathway (EUR million, %)
Source: Ipsos analysis based on 26 countries' datasets



This picture is mirrored to a large degree at the national level. Within the scope of our study, we analysed available data on food systems R&I in 26 EU Member States. Our analysis shows an estimated aggregate total of **EUR 5.5 billion** of food-related R&I spend between 2007 and 2020. While there is more even spread amongst the distribution between the ten pathways of the aggregated funding data across the 26 Member States analysed, almost one third (32%) of R&I funding did not align with any of the Food 2030 pathways.

In the private sector, this was exacerbated, with the majority of investment identified not aligning with either the Food 2030 priorities or pathways. Our study used patent data as proxy to estimate overall private sector investment in food system R&I, reaching an estimate of **EUR 93 billion** across EU Member States between 2012 and 2018[1]. Of this, 44.5% did not align with one of the four Food 2030 priorities, and almost 74% did not align with one of the Food 2030 pathways. One likely explanation for this is that private sector investments follow the individual corporate strategies of companies active in food related products and services, rather than addressing the systemic issues in food systems.

Figure 3: Patent application distribution among Food2030 Priorities, 2012-2018
Source: Ipsos analysis of Patstat data.

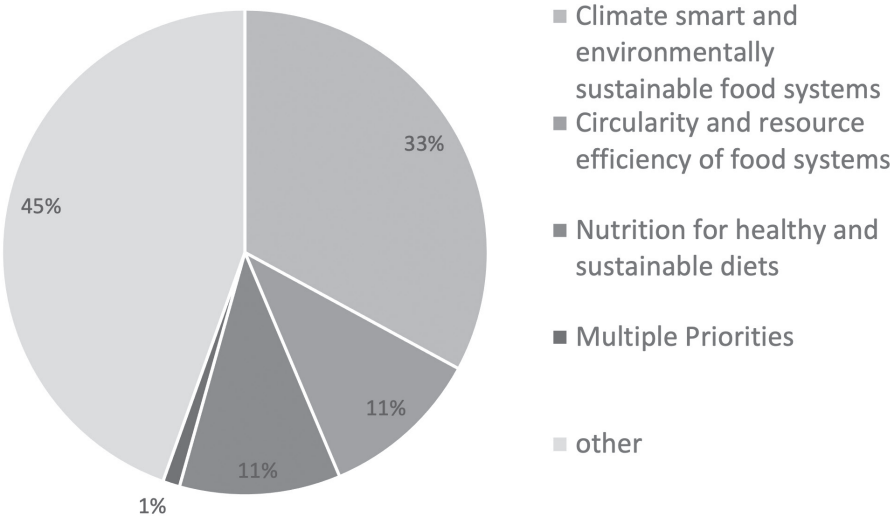
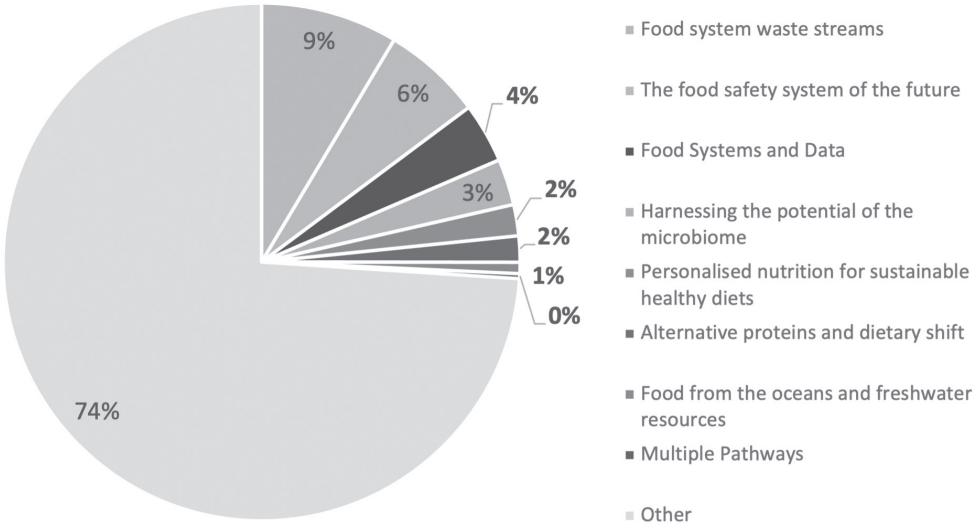


Figure 4: Patent application distribution among Food2030 Pathways, 2012-2018
Source: Ipsos analysis of Patstat data.



1 Due to data availability, the period analysed for private sector R&I spend did not fully match the period analysed for EU and national public spending

The approach taken within our study to map investments against the priorities and pathways of the Food 2030 policy in order to gain an approximation of outcomes achieved in the different areas pre-identified as pathways to change in the Food 2030 policy therefore did not prove fully satisfactory. A large share of project funding, while addressing the food system and seeking to facilitate its transformation in line with the objectives of the Food 2030 policy did not correspond to one of the ten pathways to action, but instead targeted another area. The complex nature of systems transformation means its pathways to change are numerous, and the categories used within our mapping may be too narrow to encompass these.

A second but related issue corresponds to the **non-linearity of a systems-based approach** to R&I. The nature of systems thinking, which focuses heavily on concepts of interdisciplinarity and co-creation, can make traditional approaches to attribution of impacts difficult. Interdisciplinarity "combines two or more disciplines to a new level of integration suggesting component boundaries start to break down. [It is] more than the simple addition of parts but includes the recognition that each discipline can affect the research output of the other" (ZonMW, 2020). Such influence is rarely linear but rather forges obscure causal pathways that are difficult to evaluate. This means that it can be hard to use traditional approaches to evaluation, based on identifying and assessing impacts as a series of small steps which can be used to trace the contribution of specific inputs through their conversion into activities, which in turn lead to longer-term outcomes and impacts. While the nature of our study – which is intended to map the alignment of historic expenditure with a series of policy priorities, rather than try to measure its impacts – enabled us to sidestep this issue to some extent, it remains a key point of concern when attempting to develop a comprehensive evaluation framework in order to truly understand the long-term impacts of transformational policy.

IMPLICATIONS FOR RESEARCH AND EVALUATION: PRACTICAL ISSUES OF INTERDISCIPLINARITY AND TRANS-SECTORAL PROBLEMS

In addition to the wider conceptual issues outlined above, the interdisciplinarity and trans-sectoral nature of systems transformation led to several practical issues in our study.

Candel and Pereira (2017) introduce a number of challenges related to the inter- and trans-sectoral nature of food systems policy. These include three issues of particular relevance to our mapping of R&I investment levels in food systems in Europe. The first of these relates to the breadth of sectors and stakeholders implicated in a wicked problem, and the differing priorities and interests they are likely to pursue. In the case of FNS, for example, environmental concerns may be perceived as contradictory to economic interests, which may in turn be viewed by some as undermining public health concerns. Candel and Pereira therefore highlight the need to create a shared understanding of the problem as a foundation for a resonating policy framework as a first key challenge. A second and related challenge is the need to formulate coherent policy goals that have buy-in from the different factions and design a consistent mix of policy instruments to achieve this. The vested interests of different stakeholders and sectors involved provide barriers to achieving this. The more sectors are involved, the more stakeholders need to be brought on board to buy into the narrative of change. Finally, this applies not only horizontally (i.e., between different sectors involved) but also vertically: buy-in needs to be generated from top to bottom of organisations. In the case of the EU, this would require not just the Commission to pursue objectives related to societal challenges, but also the Member States and their regions, down to the business sector and society.

Within the context of our study, this resulted in the issue faced by the study team that the inter- and transdisciplinary nature of a systems approach, as well as the nature of systems thinking itself, make it **hard to define evaluative boundaries**. The systems approach implies a broad-based and inclusive interpretation of "food systems R&I". This problem was amplified within our study by the trans-national scope of our data collection, which involved national level research in all EU Member States, meaning that any definition suffered from the potential to be "lost in translation". This posed problems when defining what was in and out of scope for our study. The approach used to identify relevant data sources therefore involved the use of two very broadly defined inclusion criteria, in conjunction with a series of pre-agreed keywords, which were further refined throughout the course of the study.

A review of national research and innovation strategies in the 27 EU Member States shows that most have **embedded R&I ambitions related to the food sector in their latest national innovation strategies**, either as a specific policy goal (Austria, Bulgaria, Germany, Ireland) or as part of a broader ambition to address societal challenges through a transformation of the food sector, often alongside the biodiversity and forestry sectors (Latvia, the Netherlands, Poland, Portugal, Romania, Spain, Sweden). Some countries, such as Finland, had already included food and agricultural R&I in strategies published in 2007. Most countries, however, only introduced it as an explicit objective more recently (in strategies published after 2018) and in many cases there is no coherent food R&I policy as such. Instead, responsibility for food-systems related R&I is subsumed within distinct agendas around agriculture, sustainability, health, education and economic growth.

For the most part, national R&I systems within Europe continue to reflect traditional policy priorities and **do not align with a systems-based approach**. Public investment in food R&I is not considered from a holistic and strategic perspective, but is instead approached in a piecemeal fashion, with Ministries for Agriculture, Economy, Education and Environment pursuing their own, often overlapping (and sometimes contradictory) policy goals. Additionally, data collected on outcomes generated is intended to monitor progress towards these individual objectives. This makes it difficult to assess progress towards systemic outcomes, as on the one hand, only partial information about certain aspects contributing to systemic outcomes is gathered, and on the other hand, trade-offs, synergies and duplications are not captured. As discussed previously, we chose to mitigate this issue by categorising spending using definitions included within the Food 2030 policy, namely the priorities and pathways defined by the European Commission. However, this approach risked missing expenditure which, while aligned with the Food 2030 priorities and pathways, was not necessarily described in a manner which allowed it to be captured by the keywords used.

Additionally, the fragmentation of responsibility for food policy (and food R&I in particular) between numerous different Ministries and other

institutions created problems both in terms of identifying relevant data (with responsibility for food R&I scattered between Ministries and Agencies) and in monitoring the outcomes of R&I investments against an overarching systems-level objective (as most data captured relates explicitly to the specific political priorities of the institution in question). It was therefore necessary to adopt an iterative bottom-up approach to data collection (casting the net widely and attempting to collect data from all parts of the system) combined with a top-down approach to data analysis, using a centralised EU policy as the common point of reference for all data collected. In reality, the majority of funding data identified fell within the remit of the Ministry for Agriculture, often complemented by limited data from the Ministry for Research and Innovation and (in some cases) the Ministry for the Economy. In many cases, data was either not consistently collected, not consistently stored, or not organised in such a way as to be able to identify food projects.[2]

Finally, it is clear that in the food R&I system, both the public and the private sectors have important roles to play. However, the requirement to calculate private sector expenditure on food systems R&I raised additional difficulties. Data collection on private sector investment is very difficult, particularly at the EU level, as there is extremely limited data available, and it does not usually provide sufficient granularity to carry out mapping equivalent to that described for EU-level and national public data collection. We therefore implemented a patent-based approach to estimating the level of private sector investment, building on a method used by Pasimeni, Fiorini, Georgakaki (2019) for estimating R&I investment levels in renewable energy using fractional counts. This allowed us to estimate a unitary cost of patents, which in turn was used to infer R&I expenditure. While patents are considered the best proxy to measuring investment levels, as they are directly linked to spending, they only capture part of all R&I activity. In the agri-food sector, patents are estimated to only represent approximately 5-10% of private sector R&I expenditure. Our study took this limitation into account when estimating overall private sector R&I spend. Our approach was felt to be a pragmatic method for understanding the scale and scope of private sector R&I investment within the EU.

CONCLUSION

In this paper, FNS is argued to be a wicked problem requiring an inter- and transdisciplinary approach to achieve (food) systems transformation. The Food 2030 Strategy is presented as a transformative strategy which aims to address this issue. We have outlined the conceptual and practical challenges this has caused for a comparative study related to the Research and Innovation (R&I) investment level in food systems in Europe we have been commissioned by DG RTD to carry out, our approaches to address these and how well they have worked.

Our research involved the identification and collation of several different national and EU datasets in order to provide a baseline picture of the overall level of investment in food-systems R&I at different levels across the EU. We have highlighted the specific challenges and limitations encountered throughout the course of this study. While Food 2030 takes precisely the inter- and transdisciplinary approach deemed necessary to address a wicked problem and provides a common framework for food systems transformation with tangible impact pathways against which Member States can measure progress, it is a novel and (to date) relatively isolated framework.

Legacy R&I policy approaches and systems still persist and were in effect throughout (most) of the period our study covers. This has implications for a retrospective mapping such as ours. These reflect a significant data gap at national level, with limited attention paid to policy priorities (such as food) which do not sit neatly within the remit of one institution, as well as a failure to capture systemic outcomes beyond the traditional R&I indicators. The Food 2030 initiative is a useful point of reference in this regard, providing a common framework for food systems transformation with tangible impact pathways against which Member States can measure progress. If food systems transformation is truly to be achieved, interdisciplinary mission-oriented food R&I strategies will need to be developed at national level with accompanying M&E strategies in order to ensure that progress towards food system is effectively monitored and measured.

Our study provided a first mapping of food systems R&I investments within the EU, but given the limitations and challenges described above, it was by necessity built using data of varying quality, completeness and granularity. To overcome this, we adopted an iterative bottom-up approach to data collection (casting the net widely and attempting to collect data from all parts of the system) combined with a top-down approach to data analysis, using a centralised EU policy (Food 2030) as the common point of reference for all data collected. Although the methodological approach described here enabled us to analyse fragmented data from multiple sources against a common transformative framework, it nonetheless represents a partial picture of food systems R&I investment within Europe.

While solutions to overcome the challenges given will usually remain partial and imperfect, they nevertheless improve on the traditional, non-systemic evaluation approaches by expanding on these and widening the scope to take in more of the edges of the hard to define evaluative boundaries than before. Gaps are still left (most notably as regards 'difficult to classify' national public and especially private sector R&I), but our study provided a useful retrospective baseline that we hope can be further refined in future research.

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