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► **To cite this version:**

Pedro Lopez-Merino, Claire Lamine. Transformative Territorial Assessment of Food Systems: A Post-normal Science Perspective. *Futures*, inPress, pp.103492. 10.1016/j.futures.2024.103492 . halshs-04747594v2

HAL Id: halshs-04747594

<https://shs.hal.science/halshs-04747594v2>

Submitted on 29 Oct 2024

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Transformative Territorial Assessment of Food Systems: A Post-normal Science Perspective

Pedro Lopez-Merino¹, Claire Lamine².

Abstract

The importance of food systems' transformations worldwide in order to achieve sustainability is recognised at all levels and scales, and the assessment of the said sustainability appears as a central element to understand the very aspects that need transforming. In parallel, the territorial scale is increasingly seen as the right one to produce such transformations, both in the scientific literature and in policy debates.

There has been a proliferation of sustainability assessment methods and tools over the past couple of decades. Yet, researchers agree that these have been mostly unable to support the aforementioned transformations. A post-normal outlook may help in doing so, and it is of interest to identify the aspects that can help rendering assessment coherent with post-normal science.

We identify three central categories that can help in doing so, and should thus be considered as central elements in sustainability assessment of Food Systems. These are *interdependencies between system components, the system's trajectories and actors' participation*. We draw elements from the scientific literature to justify the importance of these elements, and carry out a focused literature review of Food System sustainability assessment at the territorial scale to see the extent to which the methodologies proposed incorporate them.

Keywords: sustainability assessment, food systems, territorial scale, post-normal science, participatory approaches.

1. Introduction

The social and ecological damages produced by the contemporary globalised Food System are recognised at all levels and scales, from the academic to the political, and from the local to the international (HLPE 2017; Anderson et al. 2017; FAO 2017). Calls for a deep transformation of the system abound, as do proposals to change the different aspects that render it unsustainable. In parallel, a diversity of methods and tools to assess the sustainability of food systems have been proposed (for papers reviewing different food system assessment approaches, see Carlsson 2020; Fernandez-Mena, Nesme, and Pellerin 2016; Notarnicola et al. 2017; Prospero et al. 2016). Such methods and tools are aimed at better understanding where possible corrections lay in order to

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produce the much-needed change—though their capacity to foster transformations has not matched expectations (Alrøe and Noe 2016).

The territorial scale is increasingly proposed as the right one for tackling food sustainability issues (Horlings et al. 2020; Marsden 2013; OECD, FAO, and UNCDF 2016). An inclusive (system) view, taking into account the diversity of actors and elements related to food in a territory, can help understanding its inherent complexity (Ericksen 2008; Ingram 2018). The territorial scale is where many direct interactions between socio-economic and ecological processes can take place, and where a shared view of the possible trajectory of the system based on the local culture and reality can more easily be built (Feagan 2007; Lamine, Garçon, and Brunori 2019; Milestad et al. 2010). At the same time, the past decade has seen an increase in the political and social will to bring about a (at least partial) relocalisation of food production and distribution, coupled with a recognition of the difficulties produced by different lock-ins in mechanisms that depend on larger scales (Lamine et al. 2022).

A territory is not easily defined, as its boundaries are not necessarily determined by clear administrative or geographical lines, when dealing with agrifood issues. It does not necessarily correspond to a predefined area, but is related to a fabric of social, economic and biophysical processes (Lamine et al. 2019; Losch and May 2023). Before the advent of the contemporary globalised food system, the territory was also the place where most of the food consumed was produced (Hein, Ilbery, and Kneafsey 2006). We thus consider it here as the spatial area where not only food provisioning but also social relations, work, leisure and educational activities take place together in a relatively coherent manner (what the French call a *bassin de vie*). It is a “place with social meaning and endowed with responsibility and empowerment” (Norton and Noonan 2007:18).

Sustainability is yet another complex notion that defies an easy definition. Virtually all attempted definitions include a component of inter-generational solidarity: welfare obtained today should not impair that which can be obtained in the future (Brundtland 1987; Norton 2005; Sala, Ciuffo, and Nijkamp 2015), a principle that has also been used to define sustainable food systems (Gerbens-Leenes, Moll, and Schoot Uiterkamp 2003; HLPE 2014). If we include the territorial scale, sustainability can be defined as the extent to which the current state of a food system is viable through time, thus fulfilling the nutritional needs of its inhabitants while remaining within the right environmental, social and economic boundaries (Pagotto et al. 2021). The notion of sustainability is not only complex, but it also brings about high levels of uncertainty and is the terrain of different views and stakes, making it particularly appropriate for a post-normal science treatment.

Post-normal science, as conceptualized by Funtowicz and Ravetz (1993), emerges in contexts where facts are uncertain, values are in dispute, stakes are high, and decisions are urgent. Unlike traditional "normal" science, which operates under the assumption of objective certainty and neutrality, post-normal science acknowledges the complexity, uncertainty, value-laden and urgent nature of contemporary problems, particularly those related to sustainability. The evaluation of food system sustainability is thus a prime candidate for a post-normal science approach (Ericksen 2008; Levin et al. 2013; Vandermeer 2020):

- *Complexity*: Food systems are complex socio-ecological systems with intricate interdependencies among their components.
- *Uncertainty*: The dynamics of food systems, influenced by environmental, economic, and social factors, create a high level of uncertainty and unpredictability.
- *Value-Laden*: Assessing food systems involves diverse stakeholder values and interests, requiring a framework that can accommodate and negotiate these differences.

- *Urgency*: The need for sustainable transformation in food systems is pressing, with significant implications for health, environment, and society.

Despite this, sustainability assessment has been criticised for its reliance on a reductionist and positivistic paradigm (Norton and Noonan 2007; Sala et al. 2015), which, according to some authors, partly explains its inability to produce the needed systemic transformations towards sustainability (Alrøe and Noe 2016; Dorninger et al. 2020; Flood et al. 2018). A systemic approach is more often than not missing: assessment is usually carried out on specific objects such as a given food chain, product, policy or intervention, to the detriment of place-based socio-ecological systems and processes. The call is then for approaches that can take into account this inherent complexity.

To help respond to this, we have identified and brought together three specific elements that appear key for the assessment in a post normal perspective (interdependencies, trajectories and actors).

Given the aforementioned recognition of the territorial scale as pertinent to produce change, we focus on analysing these elements with a territorial focus. Our proposal can be seen as a “checklist” (Sala et al. 2015) for researchers or practitioners interested in studying the sustainability of a territorial food system from a post-normal point of view, in order to better contribute to their transformation. As a further exercise in the use of our checklist, we look at a number of sustainability assessment approaches to see the extent to which these three elements are present.

We structure the remainder of the article as follows: we first seek to further justify the choice of the above elements by gathering arguments from the sustainability literature on the issues of actors, interdependencies and trajectories, particularly within the context of food systems’ transformations. We then show the results of a brief review of the literature dealing with territorial food system sustainability assessment (and thus carry out an “assessment of assessments”), to see the extent to which the categories of our framework are taken into account when conducting sustainability assessments at the territorial scale. A discussion of our main results and its implications ensues.

2. A Post-Normal Science Checklist

To operationalize a post-normal science framework for food system sustainability assessment, we identify three central elements: interdependencies, trajectories and actors’ participation. Each of these elements aligns with the principles of post-normal science, contributing to a systemic and transformative approach. As developed in the coming subsections, these three elements permit to tackle the complexity, uncertainty and value-laden aspects of food systems, and constitute the aforementioned “checklist” of our proposal.

The first two elements of the checklist relate to the object under evaluation (the “what” we evaluate when looking at territorial food systems), whereas the third one refers to a methodological consideration (the “how” to evaluate the sustainability of territorial food systems). In the subsections that follow, we take elements from the literature to justify the inclusion of each element in a post-normal science approach.

2.1 From isolated components to interdependencies

Social scientists in the field of sustainability science have, for a number of years, proposed that attention should move from treating variables in isolation to a more explicit focus on the interrelationships that determine a system (Darnhofer et al. 2010; Hiremath et al. 2013; Preiser et al. 2021; Wells 2012), and to a better consideration of dimensions other than environmental ones in doing so (Binder, Feola, and Steinberger 2010; Etxano and Villalba-Eguiluz 2021; Hubeau et al. 2017; Ludden et al. 2018). This, as approaches to sustainability have long relied on the “normal” analysis of isolated variables, such as greenhouse gas emissions, deforestation or biodiversity loss (Binder et al. 2010;

Moragues-Faus and Marceau 2018), and have had a tendency to focus exclusively on environmental issues, to the detriment of social ones and of the interactions between them.

Post-normal science advocates for an understanding of systems as networks of interdependent components rather than isolated elements. This perspective is essential for capturing the complexity of food systems, where social, economic, and ecological interactions determine overall sustainability (Berkes and Folke 1994; Dorninger et al. 2020). Attention to the interdependencies at play when assessing territorial food system sustainability not only allows to better incorporate their complexity, but also to identify synergies and trade-offs at play that can lead to more integrated and resilient solutions (Berkes and Folke 1994), thus reinforcing the transformative potential of assessment. In this sense, a view encompassing not only ecological but also social and socio-ecological interdependencies can help identifying conflicts that lay both within the socio-economic components of territorial food systems, and between the ecological and socio-economic ones (Ericksen 2008; Jordan 2019; Stirling 2014). Understanding ecological and socio-economic systems as part of a single one is seen as one of the biggest challenges to sustainability (Bostrom et al. 2018; Johnston, Fanzo, and Cogill 2014; Jordan 2019). A direct attention to these elements can therefore help moving away from monistic/reductionist views and better favour sustainable transformations (Norton and Noonan 2007).

2.2 Considering non-linear, singular trajectories

The (much-needed) global push towards sustainability, coupled with the preponderance of the neoclassical economic discourse on international policymaking, has given way to universal sustainability views, echoing previous dictates of development policy. There is today a prevailing mainstream view that countries (usually taken as a base entity and in disregard of other scales) can move to a common “sustainable” path through the adoption of clean technologies and the use of instruments such as carbon taxes tackling specific (isolated) issues. This, much like the adoption of trade-liberalising policies were promoted to help countries walk the way from underdevelopment to industrialisation (Escobar 2011). However, sustainability itself is an evolving social construct that depends on values, social evolutions and changing scientific perspectives. Moreover, the fundamental properties of a system, including a food system, are dynamic and can change before measurements are even compiled (Meter 2019). The very object of sustainability assessment is, therefore, a post-normal science object, given its evolutionary nature, non-linearity and multiplicity of causes making uncertainty and surprises the norm (de Vries and Petersen 2009). Nonlinearities and surprises are not the exception to an otherwise stable and linear-based system trajectory, but an emerging reality inherent to its complexity (Holling 2001; Thompson and Scoones 2009), where systems are constantly adapting to inner and outer interactions (Preiser et al. 2018). Where traditional assessment of sustainability, including that of food systems, has privileged static and predefined indicators of impact, these sources of non-determination require approaches that place uncertainty and emergence at the very centre of their analyses (Norton and Noonan 2007; Jones et al. 2016; Boulton and Preiser 2021), as well as an explicit recognition of the context-dependent and evolving nature of sustainability. Each system’s trajectory and the analysis of its sustainability are thus singular—and so are the solutions to problems that are unique in time and space. A post-normal sustainability assessment that seeks to produce transformative effects therefore needs to include attention to specific trajectories, with all the non-linearities, singularities, uncertainties and surprises that these entail. By doing this, assessment develops a better contextual understanding with insight into the specific historical and future pathways shaping the sustainability of territorial food systems, and is particularly apt at adapting to the uncertainty and open-endedness that characterize them.

This consideration of these issues in the analysis of a system's trajectory means that outputs and causes cannot always be proportionally studied (Preiser et al. 2018), and that the cycles that determine a trajectory are not necessarily sequential. Adaptation and complexity imply that trajectories themselves become a subject worthy of study, above the succession of states of the elements that compose it (Allen and Prospero 2016). Therefore, different possible trajectories to sustainability can coexist (Hubeau et al. 2017), and looking at individual trajectories with their specific transformative potentials at the local scale is more pertinent to produce transformations than the use of similar methodologies and frameworks everywhere. Looking at the *potential for change* of a system, based on its previous trajectory and current interdependencies, becomes more important than analysing its components in meticulous detail (Koopmans 2017), or propose pre-determined pathways to it. We thus move to a vision of sustainable transitions that acknowledges the combinations and tensions between more determinist and more open-ended phases (Lamine et al. 2021), where each pathway is unique, and where outcomes cannot entirely be pre-determined (Hazard 2018; Lopez-Merino and Rouchier 2022; Pohl et al. 2021). We can argue, following Dorninger et al. (2020), that a transformation is in itself a non-linear, unpredictable, shift.

2.3 Taking actors into account

The inclusion of actors and stakeholders in the evaluation of the sustainability of a food system has gained a high level of attention in recent years, with consumers and representatives of different industries explicitly involved in many approaches³.

Motivations for this inclusion vary, as does the representativeness of the system that they bring in. One trend of the transdisciplinary literature makes a difference between what can be termed a 'consulting' or 'top-down' inclusion (Binder et al. 2010; Mobjörk 2010) and a 'participatory', 'bottom-up' one. The former has actors join at a certain point in the evaluation (usually at the data collection stage), while the latter uses integrated participatory methods where actors are present *throughout the process* of evaluation, from deliberation and framing of the problem to knowledge production and problem solving (Popa, Guillermin, and Dedeurwaerdere 2015). In a participatory setting, actors have a double-fold position: they are embedded beings that take *part* in the system, and they are also well-suited to identify and observe the system in order to help transforming it.

A participatory outlook appears as particularly useful for a post-normal science treatment of sustainability assessment, where incorporating perspectives and knowledge coming from diverse actors allows to better grasp their complexity. Participatory methods also ensure that the assessment process is plural and democratic, reflecting the values and interests of different stakeholders and actors involved (Garmendia and Stagl 2010; Norton and Noonan 2007) (Garmendia and Stagl 2010; Norton and Noonan 2007). Such participatory approaches can thus enhance the legitimacy and acceptance of sustainability assessments, facilitating more effective, equitable and lasting outcomes. Given that learning and change are intimately related, participatory methods can help producing transformative learning in the face of current sustainability changes (Sala et al. 2015; Wibeck, Eliasson, and Neset 2022). In the view of a number of scholars involved in post-normal, post-positivist and participatory approaches, an assessment that seeks to help shifting food systems towards

³ A Web of Science search including the words 'sustainability', 'stakeholder' and 'evaluation' (or 'assessment') gives 6,273 results on 4th October 2022. All major international organisations produce recommendations on the inclusion of stakeholders in the evaluation of sustainability problems. See, for example, <https://sustainabledevelopment.un.org/majorgroups.html> and <https://www.fao.org/policy-support/tools-and-publications/resources-details/fr/c/1331094/>.

sustainability will need to be pluralistic, participatory and deliberative (Norton and Noonan 2007; Garmendia and Stagl 2010; Mavrommati et al. 2021).

This does not mean that consulting/top-down approaches are to be discarded, in particular since they can arguably work hand-in-hand with participatory/bottom-up ones⁴. Nonetheless, excessive reliance on centralised, top-down methods may be responsible for the inability of sustainability science to fulfil its transformational role (Sala et al. 2015), and is less aligned with the post-normal perspective discussed here.

It goes almost without saying: the three aspects presented (interdependencies, trajectories and actors) are, in themselves, intricate. Trajectories are the result of the visions and interactions of actors, who adapt and engage with a dynamically evolving system, and of the interdependencies within and between its socio-economic and ecological components. It is these very visions, interactions and interdependencies that render each trajectory unique, thereby defining a territorial food system and creating its inherent complexity. As has been put somewhat poetically, “a transition is a story that is woven over time through individuals’ interactions and the complexity of their environment” (Abbott 2001). Looking at these together can be helpful in developing assessment tools that are deeply mindful of the singularity and dynamism of each territorial food system, and can therefore be a support to their sustainability transformations.

3. A study on food system sustainability assessment approaches

3.1 Constitution of a corpus of approaches

We hope to convincingly have argued for a view of the sustainability assessment of food systems that explicitly considers the inclusion of its actors, the interdependencies at play and their evolving unique trajectories. In the present section, **we look at the scientific literature of food system sustainability assessment to study the extent to which the three proposed categories are present or absent from it**. Given our premise that the territorial scale is a promising one to foster transformations, our focus is in particular on the assessment of territorial food systems.

We ignore the grey and wider literature and restrict ourselves to articles published in scholarly journals for two main reasons: first, our goal is to study the conceptualisation behind assessment, which is easier to find in standard academic publications than elsewhere. Second, the grey literature abounds with assessments and proposals that are often difficult to find (Moragues-Faus and Marceau 2018), and do not necessarily match the scientific standards of descriptiveness and referencing. We are conscious that our choice inevitably leaves aside a number of noteworthy efforts, and that some of these may have a thorough incorporation of the three elements we discuss. Nonetheless, we believe that a first assessment carried out at the level of the scientific literature is a justified one, and call for future work to be done in a more inclusive manner⁵.

⁴ A discussion already present in Funtowicz’s and Ravetz’s seminal article from 1993.

⁵ A complete, although somewhat dated, inclusive review of tools for the sustainability assessment of food systems can be found in (Freedgood, Pierce-Quiñonez, and Meter 2011), although the consideration of the elements of our proposal, including the territorial scale, is absent.

For this, we carried out a *Web of Science*⁶ search on 17 March 2021, producing 657 results. We first read the titles of these (and abstracts and keywords when clarification was necessary), in order include only those that satisfy the following three conditions:

- They propose an approach for sustainability assessment, regardless of whether it has been implemented or not. We do not use a strict definition of sustainability, and therefore the approaches selected may have different focuses (including, for example, vulnerability, security or resilience).
- The proposed assessment must refer to agricultural and food systems, comprising a variety of products, actors and practices, and not only to a specific food chain, sector, farm or type of actor (see our introduction section). Methods such as FAO's TAPE (Mottet et al. 2020, applying namely to the scale of the farm) or SEAMETH (Peano et al. 2015, applying to production chains) while interesting, are thus excluded.
- It must apply (implicitly or explicitly) to the territorial scale. Due to semantic differences in the use of terms, we are generous in the operational definition of territory (and thus we include concepts such as "city", "local" and "community-based" when they appear in the results of our query)⁷.

We then complemented the search through the snowball method, as well as by searches on Google Scholar keeping the same three conceptual filters in mind. Over 20 articles presented approaches that reasonably fulfilled our requests. We classified each of them using an analytical grid based on the elements of our approach (actors, interdependencies, trajectories) to see the extent to which each of the approaches and tools proposed took them into account.

A detailed reading meant removing a few of the selected tools and approaches since—despite what we inferred from their titles and abstracts—the actual content did not pass our above filters. A total of 14 articles were thus kept for the analysis in the subsequent section.

Flowchart 1 in the next page shows the procedure we followed.

Once the final 14 articles were identified, the following questions were used as reading guidelines to complete our grid, in light of each of the categories we have discussed:

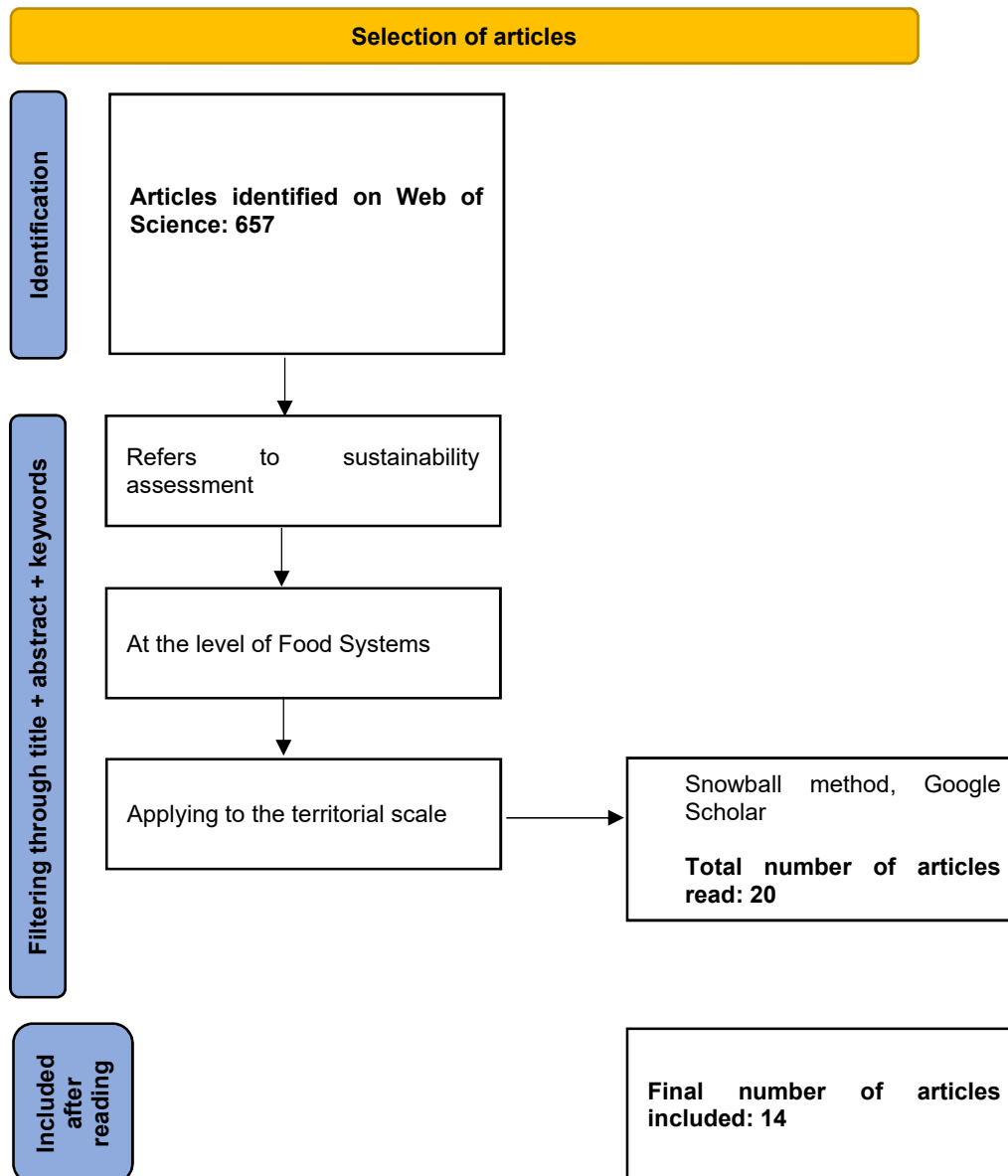
Interdependencies: Does the approach or method take into account interdependencies at play in the territorial food system? Or does it instead look chiefly at the systems' components in isolation?

Trajectories: Are trajectories taken into account, or is the assessment based on static measures? When trajectories are considered, is their non-linearity and potentially surprising nature taken into account? Does the approach allow for ongoing assessment, permitting both adjustments and changes to the very aspects analysed?

⁶ **TOPIC:** (assess* OR evaluat*) **AND TITLE:** (sustainab*) **AND TITLE:** (food OR agri*) **AND TOPIC:** (terror* OR local* OR region*). All results published up to the date of the search were included in the analysis. The results of the search can be accessed here: <https://www.webofscience.com/wos/woscc/summary/7bde618c-0a6a-4e23-b344-93390c62ed75-47f02e81/relevance/1>. We did not restrict the search to "food system", in order not to filter out approaches that are systemic while not using the term.

⁷ One of the articles found at the snowball stage (Gustafson et al. 2016) was implemented at the scale of countries, although its description makes it sufficiently clear that an implementation at the territorial level is possible and part of its initial objective. We decided to keep it.

Actors: Are actors considered in the process of assessment, and if so, at which stages? Stages can be conception, selection of indicators, evaluation, discussion of results and beyond (experimentation and/or action).



Flowchart 1. Procedure followed to select articles.

3.2 Results

The table below summarises the results of this focused review. We briefly describe each approach in terms of its name, scientific reference, objective, and whether it has been implemented in practice or not (and where). We then shortly indicate the way in which each of the elements of our framework is taken into account as per the above questions. We insert a check mark (✓) whenever a given tool or approach reasonably incorporates these elements in line with what we exposed above. Conversely, we use a cross (✗) whenever the consideration of an element is absent, or present in a way contrary to what we have exposed.

Of 14 approaches analysed, we can see that the vast majority (12, or 86% of the total) have been implemented at least once, with one of these 12 having been implemented indirectly and one at the

scale of countries (the rest were all carried out at the territorial scale). In terms of our proposed categories of analysis, we see that:

- Half of the approaches look at the interdependencies, at least partially.
- Four out of the 14 approaches look at the specificities of local trajectories.
- Half of the approaches take into account the visions of local actors at least at some point of the assessment in a participatory manner.
- Six take two or more of the elements into account.
- Two take all three elements into account.

Looking at the table globally, we see that 27 boxes out of the 42 possible ones are marked with a cross (✖). Even when an element is marked with a check (✓), only in 12 occasions it is done without a cross associated in the same box. Concerning actors, for instance, they are usually included in one stage of the assessment instead of throughout. Regarding interdependencies, we see that their presence is often at the level of a recognition, without necessarily having an actual implementation (meaning that the authors recognise the interest of including interdependencies in assessment, but fail to actually include them in their work). Trajectories only have 4 boxes with a check, with three of these not having a cross in the same box. We get back to these results in the discussion section.

More details as to the implications of these overall findings are discussed in Section 4.

Name and reference	Objective of assessment	Implemented?	Interdependencies	Trajectories	Actors
1. Sustainability of urban Food Systems (Boyer, Sarkar, and Ramaswami 2019)	Evaluation of sustainability of urban FS across four dimensions: environment, health and nutrition, equity, and resilience	Yes, to nine Indian cities	* Selected variables are independent and isolated	* Static measures that do not consider singular trajectories or non-linearities	* Use of secondary data from academic and government studies. No participatory elements included
2. Local-To-Global Approach to Community Planning and Assessment (Carlsson et al. 2017)	A tool for tracking progress toward sustainable FS that aims to balance the need for community determinacy and global cohesion	No	* Selected variables are independent and isolated	* No consideration of trajectories in the proposal nor of non-linearities	* Expert-level selection of indicators through Delphi method. ✓ The validation and evaluation is done through participatory workshops
3. Panarchy Framework (Fraser, Mabee, and Figge 2005)	Assess the vulnerability of Regional FS to shocks in terms of how wealthy, connected and diverse a system is.	No	✓ Through notions of connectivity and diversity using Portfolio Theory	✓ External shocks are seen as producing unique and unexpected consequences	* Actors are not considered in the framework proposed
4. Local Agrifood System Sustainability/Resilience Index (SRI) (Green, Worstell, and Canarios 2017)	Indicators on the sustainability/resilience of local agrifood systems at the US county level	Yes, to nine US counties	✓ Recognition of the importance of investigating interdependencies between variables, * Although not implemented.	* Static measures that do not consider singular trajectories or non-linearities	* Construction of indicators using secondary data
5. Seven Food System Metrics of Sustainable Nutrition Security (Gustafson et al. 2016)	Propose a “sustainable nutrition security” index using selected variables	Yes, at several country-level cases	* Selected variables are independent and isolated	* Static measures that do not consider singular trajectories or non-linearities	* Metrics and indicators selected through top-down workshops not including local actors
6. Ecology of alternative food landscapes (Hedberg 2016)	Use Landscape ecology to assess the ecology of AFN	Indirectly, to Greenmarket (NY state)	✓ Consideration of social, economic and ecological relations at different scales	* No consideration of trajectories in the proposal nor of non-linearities	* Use of secondary data and academic literature

7. AFSSA Framework (agri-food systems sustainability approach) (Hubeau et al. 2017)	Based on two existing frameworks (Four capital & DPSIR) Combining factual knowledge with stakeholders perceptions to identify transformation pathways	Yes, in the Flanders region	✓ Explicit recognition of the need for AFSSA to assess interdependencies. ✗ The existing implementation is a static picture of isolated variables, future iterations needed	✓ Phases of 'sustainability visioning' and identification of shared transformation pathways. Focus on 'action' rather than 'goals' gives specific trajectories. ✗ The identification is forward looking and not attentive to past, and trajectories are presented as linear	✓ Participatory choice of indicators (pre-selected by researchers), as well as of desired transformation pathways ✗ Implementation done chiefly with industry and government stakeholders.
8. Framework of food sustainability (Jacobi et al. 2020)	Selection of relevant indicators for sustainability seen as food security, right to food, environmental performance, poverty and inequality, and social-ecological resilience	Yes, to 6 case studies in Bolivia & Kenya at the county level	✗ Selected variables are independent and isolated	✗ Static measures that do not consider singular trajectories or non-linearities	✓ Transdisciplinary workshops for co-creation of indicators, as well as for their assessment
9. Holistic Sustainability Assessment Method for Urban Food System Governance (Landert et al. 2017)	Set of indicators for the sustainability of urban FS following FAO's SAFA. Good Governance, Environmental Integrity, Economic Resilience, and Social Well-Being	Yes, to Basel's FS	✗ Selected variables are independent and isolated	✗ Static measures that do not consider singular trajectories or non-linearities	✗ Indicators are pre-selected, then assessed by "expert" stakeholders, ✓ and measured partially through later interviews with TFS actors
10. Method to assess environmental, economic, and social sustainability (Liu and Zhang 2013)	Assessment methodology based on 3 dimensions of sustainability (environmental, social, economic)	Yes, to the 8 main agricultural regions of China	✗ Selected variables are independent and isolated	✗ Static measures that do not consider singular trajectories or non-linearities	✗ Selection and assessment of indicators done by experts
11. Food Sustainability Assessment Framework (FoodSAF) (Llanque et al. 2021)	Allows non-academic actors to identify pathways for making FS more environmentally and socially sustainable (five dimensions)	Eight applications in Africa & South America	✗ Selected variables are independent and isolated	✓ Assessment comes with transformative initiatives attached (funded), for each individual territory, therefore supporting	✗ Pre-selection of indicators ✓ Assessment done through participatory workshops

				specific past and future trajectories	
12. Sustainable Food Cities toolbox for action (Moragues-Faus and Marceau 2018)	Place-based and action-oriented assessment framework	Yes, to Cardiff and Bristol	✓ Output and activity-based indicators for the application of goals recognise interdependencies	✓ The relation between indicators and activities is territory-specific and not linearly predefined	✓ Goals & indicators for each dimension co-constructed participation (building on a literature review)
13. A Delphi approach to develop sustainable food metrics (Mullender et al. 2020)	Co-creation a set of indicators to measure sustainability of FS	Yes, carried out for Mediterranean regions	* Selected variables are independent and isolated	* Static measures that do not consider singular trajectories or non-linearities	* Only experts consulted
14. Sustainability assessment of agri-food systems (Peano, Migliorini, and Sottile 2014)	Indicator-based tool to monitor the sustainability in agri-food systems, based on the Slow Food vision (quality, economic, social, environmental & cultural performance)	Yes, to three Slow Food Presidia in Italy ⁸	* Selected variables are independent and isolated	* Static measures that do not consider singular trajectories or non-linearities	✓ Indicators partially selected and assessed through consumer and producer consultation, as well as experts

Table 2. Results from the analysis of assessment approaches (FS = Food System).

⁸ The application to Presidia implies a focus on specific products rather than on a systemic view of the territorial Food System. Nonetheless, the framework described can be applied to the latter.

4. Discussion

Moving towards the much-needed sustainability transformations of food systems invariably needs some form of assessment to take place (Pope, Annandale, and Morrison-Saunders 2004; Triste et al. 2014), although their localised nature and inherent complexity render the assessment task difficult. Evidence that assessment is not accompanied by sufficient changes in practices is mounting, as are criticisms of assessment approaches and tools, namely from the social sciences. Among these criticisms, we count the fact that they have an intrinsically reductionist nature (most look at components in isolation to represent complex food systems); that they are framed by underlying assumptions, values and worldviews guiding their categorization processes; that they generate processes of exclusion of certain realities (only specific environmental, economic or social variables are included, along with a strong tendency to the production of monistic indicators); that there is a dependency on available data partly due to difficulties in finding or producing more relevant data; and that they are partly governing tools, designed, framed and/or used for serving predefined political goals (Bouleau and Deuffic 2016; Gasparatos 2010; Levkoe and Blay-Palmer 2018). These objections call for methods of assessment that go beyond reductionism and include a diversity of values, worldviews and points of view, as well as different environmental, social and economic dimensions. Likewise, a post-normal science approach can help going beyond the path-dependency that assessment appears to be locked-in, be it due to its political or data dimensions.

We have attempted to contribute to this by proposing a *post-normal checklist*—an “assessment of assessment approaches” to the sustainability of food systems, proposing that they are carried out at the territorial scale, seen as the appropriate one to foster transformations. We propose three central elements needing consideration when studying the sustainability of a territorial food system, and that arguably help taking into account its complexity and context-specificities, as well as fostering its transformative potential. Whereas the majority of sustainability assessments work at the level of a specific product, policy or specific ecosystem services, our stance is to look at a local system in its entirety.

Interdependencies (between the different socio-ecological components of the systems) are the first aspect of our proposal. Their presence in the approaches analysed is nuanced: in two cases (Green et al. 2017; Hubeau et al. 2017) their consideration takes place only at the level of a recognition of the issue, and fails to be implemented. One case proposes a methodological implementation using Portfolio Theory (Fraser et al. 2005) to look at interdependencies and feedbacks between ecological and economic variables, although in practice it was not implemented. This has the disadvantage of remaining at a theoretical level and, because of this, lacks in clarity as to how to operationalise it. Two implemented approaches do include interdependencies (Hedberg 2016; Moragues-Faus and Marceau 2018).. Hedberg (2016) addresses interdependencies by employing landscape ecology to analyze alternative food networks. It emphasizes the connections between social, economic, and ecological components within food systems, highlighting how these interactions influence sustainability. The study uses two case studies to explore how these interdependencies manifest at different scales and contexts. Moragues-Faus and Marceau (2018) operationalize interdependencies by creating a holistic assessment framework that evaluates food systems through the integration of diverse data and stakeholder perspectives in order to capture the complex interactions between social, economic, and environmental factors. The latter approach has the added advantage that it creates a link with both trajectories (which are determined by the specific actions chosen) and actors (who are the ones choosing the actions); therefore further satisfying our proposal in which the intricacy of the three elements is also central. The sustainability of territorial food systems having a high degree of aggregate complexity (de Vries and Petersen 2009), it is important to pay closer attention to the relational and

process-based nature of the phenomena studied, in order to tackle the “wicked” (Rittel and Webber 1973) and “messy” (Norton and Noonan 2007) problems we are confronted with.

An interesting fact comes from looking at the presence of trajectories, the second element of our checklist, in our selected approaches. We can see that in all applied methods, their consideration is related to a form of action: either the focusing on actions instead of goals (Hubeau et al. 2017), the funding of specific transformative initiatives related to the assessment (Llanque et al. 2021), the territory-specific use of activity-based indicators (Moragues-Faus and Marceau 2018), and assessing the vulnerability of food systems to future shocks (Fraser et al. 2005). This is an encouraging finding, given our reckoning that one of the main current challenges in sustainability assessment is how to link it to changes in behaviours: since the consideration of specific and non-linear trajectories is done in tandem with action, it can open the way to such possible changes. Moreover, in all cases the consideration of trajectories includes both past and future pathways, and is done in a non-deterministic (open-ended) way, in which each territory is subject to a singular pathway of sustainability. As ecological issues are underpinned by uncertainty, ignorance of outcomes and complexity (Akbulut and Adaman 2020), this open-endedness is a welcome feature. These four selected papers operationalize trajectories through various methods: Hubeau et al. (2017) use a framework to identify dynamic transformation pathways through stakeholder co-creation; Llanque et al. (2021) employ the a hands-on assessment framework to study sustainability pathways, highlighting evolving "spirals of change"; Moragues-Faus and Marceau (2018) apply territory-specific indicators to capture unique, non-linear sustainability paths; and Fraser et al. (2005) assess food system vulnerabilities by integrating past and future risks, emphasizing non-deterministic and dynamic trajectories.

The inclusion of actors—participation—happens relatively often, although only in three of the approaches studied their presence is throughout the assessment instead of at a given stage only (Jacobi et al. 2020; Moragues-Faus and Marceau 2018; Peano et al. 2014). As discussed in subsection 2.1, this relates to the question of whether these three approaches can be classified as consultative (top-down) or participative (bottom-up). All three approaches engage actors and stakeholders throughout the assessment process in a continuous and integrated manner. The methods used are participatory workshops for co-creating the very framework used (Jacobi et al. 2020), or its indicators (Moragues-Faus and Marceau 2018; Peano et al. 2014).

The participatory methodologies employed in these three papers led to context-specific discussions essential for the advancement of sustainable food systems. In Moragues-Faus and Marceau’s study, the transdisciplinary workshops and co-creation of indicators facilitated discussions on local sustainability challenges and policy recommendations, in order to promote stakeholder engagement. In Jacobi et al.’s study of food systems in Kenya and Bolivia, transdisciplinary co-creation and participatory workshops fostered debates on sustainability challenges, relevant indicators, and potential pathways for sustainable transitions. Similarly, in the Slow Food Presidia Project by Peano et al., consultations with consumers and producers and participatory workshops led to vital discussions on preserving local food heritage, balancing economic, social, and environmental goals, and formulating practical implementation strategies. These participatory approaches all seek to highlight the importance of stakeholder involvement in developing actionable, locally-relevant sustainability assessments.

As per our presentation, effective participatory science in the context of post-normal science can be characterized by key criteria that ensure meaningful engagement and impactful outcomes. One can first think of diversity, that is involving a broad range of stakeholders including marginalized and underrepresented groups, to incorporate a variety of perspectives and experiences in order to create

an “extended peer community” (Funtowicz and Ravetz 1993; Popa et al. 2015). Clear objectives and goals must be established by such a community, providing a common direction and purpose for all participants. Transparency in communication is a second one, with open sharing of data, methods, and findings to build trust and collaboration among stakeholders and a “socially robust” process (Popa et al. 2015). Empowerment and capacity building are necessary to equip participants with the tools, knowledge, and skills required for effective contribution, fostering environments where stakeholders can co-create knowledge and solutions. Continuous feedback and adaptation mechanisms should be in place to ensure the project remains relevant and effective over time (Funtowicz and Ravetz 1993). If these criteria are not met, participation can be at best a consultative effort and at worst a façade serving predefined goals.

The studies by Moragues-Faus and Marceau (2018), Jacobi et al. (2020), and Peano et al. (2014) can be seen as exemplifying effective participatory science within the post-normal science framework. They incorporate diverse stakeholder engagement through continuous and integrated participatory workshops, ensuring transparent communication and co-creation of sustainability indicators. These approaches empower stakeholders by involving them in decision-making processes and adapting to feedback, thereby creating socially robust and context-specific solutions.

The Sustainable Food Cities toolbox for action (Moragues-Faus and Marceau 2018) deserves some further attention, as it is the only approach that addresses our three proposed categories in a positive way (given that Hubeau et al. (2017) only recognises the issue of interdependencies, without including it in their approach). In this, their approach is the closest we can give to a recommendation on how sustainability assessment of territorial food systems *could* be done, if it is to fulfil its transformative potential. Its local, participatory and transformative vocation (‘the aim was to collectively develop a flexible toolbox that provides a common narrative to map and encourage action towards sustainability in the city’, p14.) is in close alignment with the elements of our checklist. Our recent work sheds further light on how participatory work that is mindful of interdependencies and trajectories can help fulfilling a transformative potential (Lamine et al. 2022; Lopez-Merino 2023)⁹. Although proposing a specific framework on how sustainability assessment should be carried out is beyond our intention here, we believe that sharing experiences and lessons is a worthy effort in order to help creating a global movement of territorial transitions.

An element that needs mentioning, however, is the time and resource-intensity that assessing territorial food system sustainability through the incorporation of actors, interdependencies and trajectories entails. The organisation of several workshops and a follow-up of actions is essential, thus demanding expenses and a level of engagement on the part of participants that have elsewhere been identified as potential difficulties inherent to such approaches (Peuch and Osinski 2020). This is perhaps the most complicated of all difficulties in transdisciplinary projects, and one that demands an immersion and commitment from researchers that may not be desirable or accessible to everyone, thus reinforcing patterns of reductionism, extractivism and centralisation that abound in the academia, and to which all of us scholars contribute to some degree (Anderson et al. 2021; Anderson and McLachlan 2016). On the same line, the sharing of experiences amongst different territories in which researchers have immersed themselves should be a central element in the study of sustainability transitions, above the detached comparison of sustainability indicators¹⁰.

⁹ See also the [l'Assiette et le territoire](#) project, funded by Fondation de France, that seeks to co-construct a shared understanding of local transition mechanisms in a transdisciplinary manner.

¹⁰ The [ATTER](#) project, an international network of exchange in which the authors participate, is built around the sharing and comparing of different transition experiences and tools between 16 territories in five countries.

Outside of the territorial scale of Food Systems, we know of two examples that appear to fulfil our guiding principles and that are worth mentioning, particularly since they could in principle be adapted to territorial food systems. The LUME method (Petersen et al. 2020), consists of a tool to analyse the agroecological transformation of agroecosystems (developed in a Brazilian context marked by the presence of family farming) in terms of their autonomy, responsiveness, economic and ecological relations, and economic performance. Building on a range of theoretical elements, LUME proposes is to evaluate and discuss in a participatory manner the trajectories of the said agroecosystems in terms of their interrelationships, power relationships, etc. Likewise, the aforementioned effort by FAO called Tool for Agroecological Performance Evaluation (TAPE, Mottet et al. 2020) has been successful in creating a framework currently used to analyse the sustainability of farming systems (and not of territorial food systems as presented in this article), and that includes elements of contextualisation through participatory consultation as well as analyses of past and future trajectories. Both LUME and TAPE include a wide range of stakeholders at different stages of the assessment in order to co-create it, validate findings and develop action plans, thus fostering a sense of ownership that ensures that assessment outcomes are relevant and actionable. Likewise, they consider ecological, economic and social factors in interaction, providing a global view of sustainability. Finally, the consideration of trajectories appears as present also as historical data and future scenarios in farming systems are taken into account. Further work investigating the adaptation of these to the scale of territorial food systems, as well as a deeper look into how the principles of our proposal are applied, could be useful to increase the number and variety of the approaches so far identified.

5. Conclusion

We have made a proposal to approach the sustainability of food systems based on the consideration of interdependencies, trajectories and actors, and used it to analyse 14 existing assessment tools at the territorial scale. Our approach is inspired from the tenets of post-normal science. We see the elements of our proposal and the consideration of the territorial scale as having the potential to guide sustainability assessment towards a better incorporation of local complexities, and creating the necessary shifts in individual and collective behaviour that are urgently needed. The agroecological transition, despite having an undeniable technical component, is not a technocratic affair, and the inclusion of actors in a bottom-up fashion, the consideration of the trade-offs and interdependencies that define a system above fixed indicators of variables, and an increased attention to specific and non-linear trajectories is in itself a change of paradigm.

Acknowledgements

The authors wish to thank Gaël Plumecoq, Danièle Magda, Armelle Mazé (INRAE) and Juliette Rouchier (PSL), as well as to the anonymous reviewers for useful comments to the paper's draft. Pedro Lopez-Merino's work was initially supported by the Agency for Ecological Transition (ADEME), and later by the French government, through the UCAJEDI Investments in the Future project managed by the National Research Agency (ANR) with the reference number ANR-15-IDEX-01. This work has been carried out within the ATTER project, which has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101007755.

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