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Current Opinion in Environmental Sustainability

Systems thinking on intensification and sustainability: systems boundaries, processes and dimensions

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'Sustainable intensification' is gaining popularity among academics and donor agencies without much examination of the ambiguities in both terms, made worse by combining them. The terms can be made more serviceable by distinguishing between *definitions by extension* and *definitions by intension*. Difficulties with the term 'intensification' are addressed by considering the System of Rice Intensification (SRI). This reverses Green Revolution thinking about intensification as a matter of increasing material inputs. Changes in crop management can raise food output by reducing such inputs, with increased reliance on knowledge and management that use available resources more productively and sustainably. Its initial increases in labor inputs are usually transitory.Conjunctions of different disciplines and different levels of analysis and action are considered with reference to the factors of *nestedness* and *contingence*. Subjects bearing on sustainable intensification which can benefit from disciplinary convergence include: biogeochemistry to address problems of climate change; part-time farming to adapt to changing economic opportunities; and symbiotic endophytes that can enhance crop health and growth. The concept of 'causation' is disaggregated to consider 'processual' as distinguished from 'mechanistic' causation. Systems thinking is likely to be more productive for addressing interactions within and between subsystems rather than for theorizing about systems as a whole.

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Current Opinion in Environmental Sustainability 2014, **8**:89–100

This review comes from a themed issue on **Sustainability governance and transformation**

Edited by **Paul C Struik** and **Thom W Kuyper**

For a complete overview see the Issue and the Editorial

Received 12 February 2014; Revised 10 October 2014; Accepted 14 October 2014

Available online 4th November 2014

http://dx.doi.org/10.1016/j.cosust.2014.10.010

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Introduction

Systems thinking runs the risk of becoming abstract and all-encompassing as most things can be considered as related in some way to everything else. Moreover, establishing interconnectedness does not necessarily lead to purposeful action [1]. Delineating the **boundaries** of systems is always essential, being logically precedent to other considerations. However, more important for guiding decisions and actions is identifying and agreeing on what are the key **processes** within the system(s) of interest and on the interrelationships among these processes, as well as the **dimensions** along and within which these processes operate.

Specifically for dealing with the adequacy and sustainability of food systems the outer boundaries of food systems need not be sharply drawn or fully agreed upon as the workings and interactions of the subsidiary subsystems are usually more relevant and more comprehensible than assessments of the full system itself. Developing an appreciation of subsystems nevertheless requires thoughtful attention to the boundaries between and among them, if not a preoccupation with the overall delimitation of the food system. There is need to identify subsystems in order to understand their interactions, bearing in mind that these boundaries are mental constructs rather than being ontologically real [2].

Further, it is important to be clear about the **goals** of activities within systems, since at least a whiff of teleology provides some of the needed glue to make the analytical enterprise hold together. Having a clear concern with understanding and improving the capacity of food systems to meet people's nutritional needs sufficiently, economically and sustainably will anchor and direct discourse as without a firm grasp on goals, the elegance of systems formulations is likely to supersede their efficacy.

From a systems-perspective, the many sets of actors or agents involved in feeding the world must always deal with the multiple influences of **context**, that is, with the many parameters and aspects of environment that condition the pursuit of multifaceted objectives. Actors cannot just pursue objectives but must at the same time cope with and capitalize on the feedbacks that operate in many directions. So all this connectivity makes prediction and control at the system level something between difficult and impossible.

A better understanding and more feasible guide to action will derive not from trying to map out all of the connectivities within the whole system as an initial exercise. Rather it will be more productive to identify and then

tackle problems that are evident *within and between subsystems*. Doing this in holistic terms means framing and assessing these subsystems in terms of goals (and values) and of contexts that transcend particular subsystems, not separating and focusing particularly on the functional elements of discrete subsystems.

Defining sustainability and intensification in appropriate terms

Our thinking about boundaries can be made more incisive by considering the difference between two kinds of definitions: *definitions by intension* and *definitions by extension* [3]. This distinction is very relevant for considering the concepts of sustainability and intensification.

How often do we hear it asked *whether something is sustainable, or not?* Or whether some production process is *intensified or not*? While dichotomous formulations like this may be qualified and excused as just semantic shorthand, they generate unnecessary confusion and lead to analytical dead-ends because of the way that they conceive phenomena in terms of boundaries, rather than focus on core concerns.

Discussions of both sustainability and intensification are repeatedly framed as being **matters of kind**, when by their nature they are **matters of degree**. It is true that our minds are neurologically so constituted that we perceive and reason primarily in terms of categories (concepts), with quantitative gradations being cognitively secondary to qualitative classifications [4]. However, this does not mean that we cannot and should not address complex phenomena like sustainability and intensification with more subtlety than the crude categorical thinking that is the antithesis of systems thinking.

Definitions by extension

Such definitions are concerned primarily with ***boundaries*** and with extents and limits, more than with core meanings and essences. Definitions by extension stipulate which things, actions, feelings, traits, etc. belong **within** a particular category, and then by implication what things are conversely **outside** the domain of that definition. Such thinking proceeds by making dichotomous distinctions between what is encompassed within a definition and what is not.

Extensional conceptions of phenomena imply that all things which fall within the boundaries specified by a particular definition have enough in common that they can and should be grouped together meaningfully within that category. Those things that are excluded by a definition — invariably a huge residual category — have in common (only) that they do not share the specified features.

This way of thinking tends to regard as homogeneous whatever things satisfy the criteria of an extensional definition. Whatever things get consigned within a conceptual 'box' are considered as belonging together, even if they differ in many other respects. *Criteria* for distinguishing (dichotomously) between what falls *within* a category and what is *outside* that category are essential for extensional definitions, but what become operationally important are the delineations of boundaries.

Definitions by intension

This kind of definition is *concerned*, conversely, more with ***core meanings*** than with boundaries. These meanings provide necessary and sufficient criteria of *shared characteristics* that justify the inclusion of similar things within a category, rather than with criteria that exclude all other things by the demarcation of boundaries. Intensional definitions focus on whatever characteristics represent, conceptually, the *essence* of a particular categorization, rather than emphasize criteria that create *contrasts* between things within and outside of the category.

With intensional definitions, one considers phenomena that diverge from, deviate from, or are at some conceptual distance from the core meaning of A as being, to an extent or a degree, *not-A*. But they are not excluded by a boundary or by some contrasting criteria. Intensional criteria are thus more disposed to unite than to differentiate. The resulting differentiations are more matters of degree than of kind. Assessing proximity to, rather than distance from, core concepts or criteria is thus centrally important for intensional thinking and discourse.[1]

Relevance to sustainability

The distinctions between these two kinds of definitions are particularly relevant for consideration of the term **sustainability**. Most discourse these days treats this concept as something that is known and can be defined by extension. How often is it asked whether is something sustainable or is not? This is an unanswerable question for any timeframe beyond a few months or at most a few years. It presents an either/or characterization that is independent of context and contingence.

The *boundaries* or *limits* of sustainability in the future are inherently unknowable in our present time. Future conditions are too variable and indeterminate to draw conclusions about even medium-term sustainability with any certainty. While there can be meaningful definitions of sustainability *by intension*, as discussed below, definitions of sustainability by extension are not tenable.

People can make probabilistic statements about what is likely to be ***un***sustainable in subsequent decades with some empirical, even scientific justifications. However,

[1] I appreciate a reviewer suggesting that a third category — ostensive definitions — be considered in this regard and will consider this in the next footnote.

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