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Beyond ecosystem services: a food security perspective

Stefano Balbi [a] and Ferdinando Villa [a,b]

Food is a primary provisioning ecosystem service. The concept of ecosystem services only focuses on the flow of services from nature to humans and doesn't consider human flows, which include both the flows from human to nature (i.e. the co-production of ecosystem services or environmental pressures caused by humans) and human to human flows (i.e. social flows). Neglecting human flows is a main issue for modelling food provision within the ecosystem services framework, especially so under a food security perspective, where food access greatly depend on economic entitlements and social networks. We use the example of food security to provide a blueprint for modelling the sustainability of provisioning ecosystem services by incorporating human flows. We adopt an agent-based perspective that allows not only to capture critical flows between agents, but also to tag social agents with heterogeneous roles and behaviors. In complex coupled human-natural systems individual human behavior affects the emergence of collective outcomes of natural resource management. We conceptually model household behavior in the context of food provision within a rural village by framing it into a social-ecological governance compass based on four cardinal directions: differentiation, conformation, cooperation and competition. We argue that by acting together towards diet diversity, differentiation and cooperation may stimulate the rise of human flows that make a rural community more food secure. When generalized to the ecosystem services paradigm, the consequences of this study stand out. From a descriptive point of view scientists could draw more informed conclusions on both the environmental and social sustainability of the ecosystem services dynamics. From a normative point of view science could inform policymaking on how to stimulate the human flows that better optimize the flow of benefits from nature to humans.

Keywords: ecosystem services, social-ecological systems, self-governance, food security, human behavior.

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1. Introduction

Ecosystem services (EServ) are defined as "the flows of value from Nature to human societies as a result of the state and quantity of natural capital" (TEEB, 2010). After decades of silent development starting in the sixties (e.g. Coase, 1960; Krutilla, 1967), a structured approach to EServ successfully emerged with the Millennium Ecosystem Assessment (MA, 2005) and since then the EServ framework has gained much attention in both the literature and public discourse. Well-established conceptual models and computational methodologies are improving the accounting of environmental values and addressing an increasingly interdisciplinary research field (Bagstad et al., 2013).

A state-of-the-art EServ framework like that of Villa et al. (2014), not only showcases the source and the destinations (use) of these flows, but also identifies the possible barriers that they might find on the way (Fig. 1).

On the one hand EServ research has proven incredibly valuable to ecological research to prove its tangible implications to human wellbeing —at the cost of adopting a clearly anthropogenic perspective (Sagoff, 2008); on the other hand, it has forced social scientists, and in particular economists, to start reintroducing (Gómez-Baggethun and Naredo, 2015) environmental variables into their models.

Among the various EServ considered in the MA (2005) food provision is particularly challenging to fit into the existing frameworks. The main problem is that EServ focus on the flow of services from nature to humans. The issue of food provision however, requires additional human flows to be taken into account:

1. human to nature flows; and
2. human to human flows.

Here flow is an umbrella term used to include (unidirectional or bidirectional) financial, material, energy and information flows

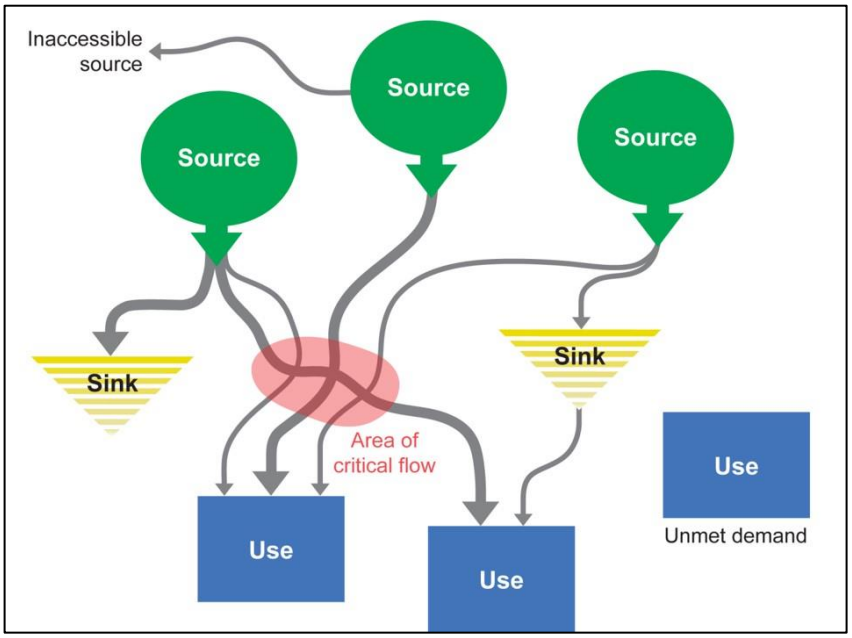

Figure 1: The ARIES framework as in Villa et al. (2014).

The first point is relevant as agri-laborers participate to the food provision process by working hand in hand with the basic ecosystem functions—supporting services in EServ parlance like pollination and soil fertility—with their own work (human labor) and inputs (organic and chemical fertilizers). However, agri-laborers also exert pressure on the soil productivity, for example with extensive mechanical soil disturbances and *in situ* burning of crop residues (Verhulst et al., 2010). On the one hand the human to nature flows refer to the generic issue of EServ co-production, i.e. how human labor co-produces EServ (Challenge 1: Bennett et al., 2015; Proposition 2: Berbés-Blázquez et al., 2016; and for food security, Fig. 1: Poppy et al., 2014). On the other hand they also suggest to account for the potentially negative effect of the human involvement in EServ provision, as discussed by Nassl and Löffler (2015) who combine the EServ and the DPSIR frameworks.

The second point, human to human flows, enables the possibility to analyze how food provision affect food security beyond food availability. This issue seems particularly related with the assumed trickle-down effect of EServ (Berbés-Blázquez et al., 2016), while in fact social relations largely mediate access to provisioning EServs. In the context of the pillars of food security (Barrett, 2010), food availability is the availability of quality food from domestic production and imports, including food aid programs. Food access on the other hand, reflects the ability of individuals and households to acquire appropriate food for a nutritious diet through their social network or market mechanisms, mainly based on their entitlements[1]. For example, human to human flows via the social network can play a key role for borrowing food and money when the availability of calories from self-production and market access is insufficient.

This article builds on the example of food security to provide a blueprint for modelling the sustainability of provisioning EServ, within a coupled human-natural system, by incorporating human flows.

2. Individual human behavior and system governance

In the following section we describe how the food provision problem changes when all human flows are included in a typical EServ framework. In order to do so we need to add two further elements to the discussion.

First, to include human flows requires a methodology that can take into account human behavior. In this regard agent-based modelling (ABM) provides the proper methodological perspective. ABMs are computationally intense and micro-detailed simulations where many heterogeneous human and natural agents can interact at multiple temporal and spatial scales through predisposed rules. The ABM perspective (Bonabeau, 2002) builds on the network perspective (as suggested for EServ: QUINTESSENCE Consortium, 2016) as it allows not only to capture critical flows between agents, but more importantly, to tag social agents with heterogeneous roles and behaviors[2].

Second, the ABM method works by observing collective behavior, for example in terms of natural resource utilization at the aggregate level, as emerging from individual interactions. We thus need a conceptual framework that can provide the guiding principles for social agents' micro-level decision-making. The literature on the governance of the commons suggests a way ahead. The research on sustainable management of natural resources also originates from the seminal studies that

[1] Entitlements constitute the set of commodity bundles over which a household or individual can establish command (Sen, 1983).

[2] Balbi and Giupponi (2010) provide a thorough review of ABM applied to sustainability issues, while Filatova et al. (2013) edited an Env. Mod. & Soft. Special issue on AMBs of social-ecological systems (SES: Berkes et al. 2008).

led to the EServ framework. While early research emphasized the need for government control or privatization (Hardin 1968), more recent empirical work has highlighted that communities are often capable of overcoming the dilemma and achieve sustainable resource use through cooperative self-governance (Ostrom, 1990). Ostrom (2009) shows how this type of self-governance is likely to be a result of environmental conditions—governance is a dynamic process —including leadership and social capital.

This part of our study complements Ostrom's work by using governance as a static social structure to infer individual behavior and analyze how this behavior influences agents' coevolution and, ultimately, feeds back into the system's structure. Social-ecological governance is here interpreted a set of boundary conditions (at initialization) of economic and personal behavior driving individual objective functions.

The social-ecological governance compass (Fig. 2), inspired by the political compass of Maddox and Lilie (1984) and Lester (1994), is a 4 by 4 grid where the horizontal axis represents economic behavior and displays *cooperation* at its left side and *competition* at its right side, while the vertical axis represents personal behavior and displays *conformation* at the bottom end and *differentiation* at its top end.

Economic behavior is about how the individual agent chooses to relate himself with the other agents for the purpose of achieving his goals. From a social-ecological perspective these goals may include EServ utilization, natural resource consumption and ultimately human wellbeing. Cooperation[3] is the process of working or acting together for common or mutual benefit, as opposed to working in competition for self-seeking benefit. Competition arises when at least two parties strive for a goal which cannot be shared or which is desired individually but not in sharing.

Personal behavior is about how the individual beliefs and values relate with the existing social norms. Conformation is the process of matching individual behavior with the dominant social norms, while differentiation—as in psychological differentiation (Witkin et al., 1974)—is the process of affirming the individual unique identity against social norms.

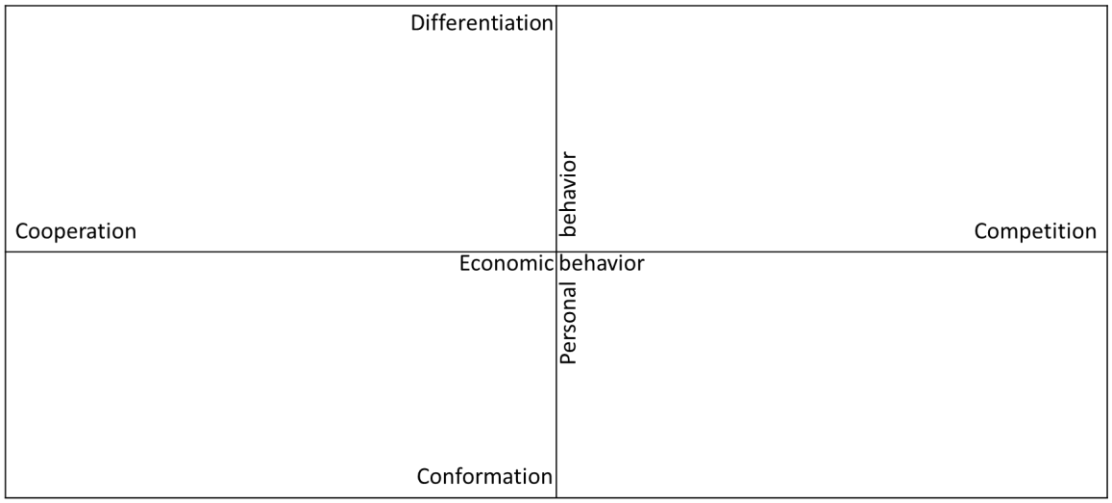

Figure 2: The social-ecological governance compass.

[3] See Axelrod and Hamilton (1981) for a computational analysis on the theory of cooperation.

3. The case of food provision

The issue of food provision is appropriate to showcase how the explained governance framework can build on the EServ paradigm because food provision is a typical EServ that is interdependent with the human agricultural activities and because there exist various and confronting philosophies of agri-food systems that can match this categorization. A review by Rausser et al. (2015) describes two main global storylines: the Industrial Food and Agricultural industry (IFA) and the Naturalization Food and Agricultural paradigm (NFA). While the first is the classical large scale multinational corporations driven type of paradigm (e.g. *Monsanto* industrial food production and *Walmart* food distribution system), the second captures a multifaceted movement of food sustainability revolving around key concepts like: local, small and organic (Pollan, 2001), slow food (Petrini, 2003), agroecology (Gliessman, 2009), food sovereignty (Patel, 2009) and diversified farming system (Kremen and Miles, 2012).

Inspired by this analysis and by a recently developed empirical ABM of rural household (RH) food security in a developing country, in the following we apply the social-ecological governance compass. The ABM depicts a representative village located in the Zomba District of Malawi (Dobbie and Balbi, 2015) where agriculture continues to be rain-fed, leaving smallholders vulnerable to climatic shocks (Sahley et al., 2005), whilst high population densities, small plot size and poor soil quality further compound food insecurity. Table 1 captures four stylized *food security narratives* that describe RH behavior within their village. Table 2 applies them to a practical case of a village in Zomba District, Malawi.

Some key features of these behaviors can be highlighted to inform an AMB of household decision-making. In particular the common key variables that take different values according to the four social-ecological governance settings are:

- Objective function of the RH;
- Scale of the objective function of the RH;
- Access to information of the RH.

Table 1: SES governance compass: village food security.

1. Cooperation & Differentiation The RH plants in order to maximize crop diversity at the village level, so it differentiates its cropping pattern from the other RH to later barter and increase diet diversity.	**2. Differentiation & Competition** The RH chooses the cropping pattern that maximizes its profit, the objective is to have a more valuable commodity (diversified quality) to be exchanged at the market (e.g. cash crop).
4. Cooperation & Conformation The RH produces the socially preferred crop and then the produce is aggregated to that of others producers and shared equally.	**3. Competition & Conformation** The RH produces the socially preferred crop and maximizes the possible yield (e.g. seeds and fertilizer subsidies are meant to influence this behaviour) in order to have more commodity to be exchanged at the market.

Table 2: SES governance compass: A village in Zomba District, Malawi.

1. Cooperation & Differentiation The RH maximises crop diversity choosing a mixed cropping pattern with different proportions of maize, pigeon pea, sweet potato, cassava, fruit trees, and vegetables.	**2. Differentiation & Competition** The RH maximises profit by planting tobacco, chilli, or cotton.
4. Cooperation & Conformation The RH plants maize and shares the produce with the community that has provided the labor needed to work the land.	**3. Competition & Conformation** The RH maximises the yield of maize, using all the available inputs subsidized by the Government (e.g. hybrid maize seeds and chemical fertilizer), and sells the produce at market.

Cooperation and Differentiation imply that the RH's objective function is the village diet diversity, therefore the scale of his objective function is the community level and the degree of access to information about other RH's food provisioning behavior is relatively detailed.

Differentiation and Competition imply an individual scale objective function focusing on profit and some degree of information on other's strategies.

Competition and Conformation imply an individual scale objective function focusing on yield and a relatively limited level of access to information, as for example the socially preferred crop.

Cooperation and Conformation imply a community scale objective function focusing on yield and a relatively limited level of access to information.

Of these four cases, the first one is ideal to display the social flows that extend the EServ scope to a wider set of beneficiaries. It displays resource optimizing unidirectional and bidirectional interactions like:

- Exchange human labor at crucial times of the season;
- Sharing of unused ingredients that would go to trash;
- Sharing of knowledge about farming practices, good nutrition and recipes;
- Extra portions of meal to be delivered to other RH;
- Invitations to join a meal to other RH individuals;
- Exchanges of seeds and food commodities to increase diversity of diet;
- Exchanges of portions of meals in different periods in time to cushion temporary scarcity (i.e. food banking).

These social flows happen regularly in rural communities in developing countries, but are currently taking off in the western world as well, with different modalities, boosted by the new technologies. The explosive development of information and communication technologies and social medial have empowered and connected individuals locally and across the world with massive implications for the accounting of social flows. For example, peer-to-peer food initiatives, like P2P food lab[4] are contributing to change the culture of food at the local level towards the naturalization food and agricultural paradigm. Quoting from their website: '*we blur the distinction between food passive consumers and active producers to create a new category of "producers" who both benefit. It also means that you plan food at local level, with neighbors, on a voluntary basis*'.

[4] Other examples are Feastly, Casserole Club, Coockening.

The second case is the well-known market driven paradigm and relies on market efficiency to optimize its distributional performances. The quest for profits is meant to stimulate technical excellence and ultimately yield maximization. This is the paradigm of the International Monetary Fund and World Bank inspired liberalization reforms (Dorward and Kydd, 2004; Chinsinga, 2007; Patel, 2009). However, this system is not able to capture social informal exchanges, while these exchanges, both legal and illegal ones, are booming under the radars, hampered by the economic crises and by the new technologies (like peer-to-peer). Additionally, the emphasis on profit rather than on nutritious potential and dietary intake makes it quite a risky social-ecological governance paradigm from a food security perspective, as opportunity cost may drive agricultural entrepreneurs to invest on non-food crops beyond the social optimal level (e.g. Anderman et al., 2014). Finally, the food distribution chain has proved to catch the higher fraction of value added over food producers who are ultimately incentivized to underpay the labor force to stay conveniently in the gross market. This produces a negative feedback on food security as agri-laborers cannot develop the entitlements to make their household food secure (On the capability approach: Burchi and De Muro, 2016).

The third case is the current main storyline of Zomba Region villages (Southern Malawi) where the market system is not developed as intended by the liberalizing reforms and the social norms of what to grow are widely and voluntarily accepted. Food preferences, are key in this regard: most of the residents wouldn't consider satisfactory a meal without maize (Dorward and Kydd, 2004; Chinsinga, 2007). Thus maize has become the main value reference at the local markets and is considered a strategic commodity even if it's a climate vulnerable crop given the local conditions.

The fourth case captures the behavior of centrally controlled economies, which also raise serious concerns about sustainability (On massive grain farms: Grey, 2000). The main advantage is the elimination of inequalities within the community so that everybody is exposed to the same level of food security. However, at the village level it can turn risky from a food security perspective both in terms of food availability—even mild weather shocks can trigger a famine, as describe in Dorward and Kydd (2004)—and diet diversity.

In Fig. 3 we design an extended and agentized EServ framework of a self-sufficient local food provision system, much in line with the first case presented above. The source of EServ is the watershed and the land where the basic ecosystem functions take place. The crop fields and the orchards act as transaction points: catalyzers where the EServ value is generated by transforming the ecosystem functions into calorific and nutrient potential. Farmers and households who directly access and interact with the supporting ecosystem functions are the primary beneficiaries who use (blue arrows) the provisioning EServ by consuming the food, but they also co-produce the EServ by means of their active farming activities (red arrow). Although this category of primary beneficiaries reminds of the concept of farmer as landscape steward (Raymond et al., 2016), unfortunately agri-laborers

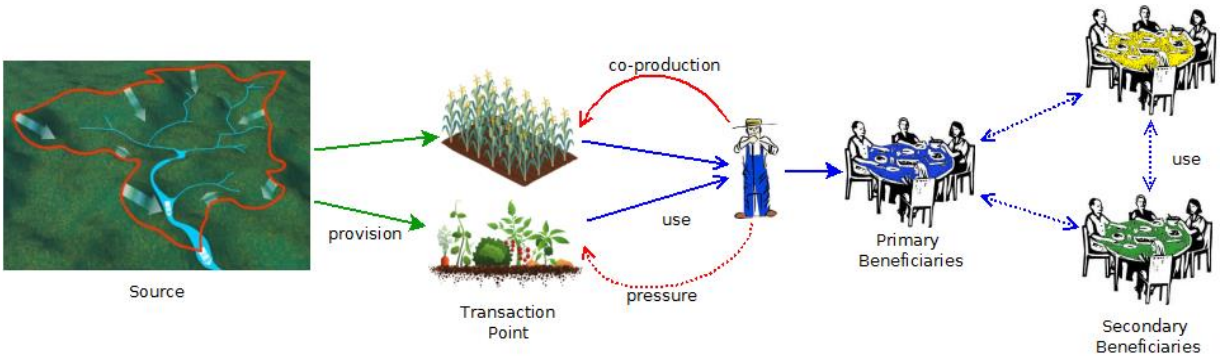

Figure 3: An extended and agentized EServ framework applied to food provision.

might also put pressure on the ecosystem functions with certain farming practices, like deep tillage (red dashed arrow).

Moreover, there exists a network of households constituting the secondary beneficiaries, who are not interacting directly with the ecosystem but are indirectly receiving the benefits by interacting with other beneficiaries (blue dashed arrows).

The same framework could be easily adapted to accommodate the inclusion of market transactions and distant interactions (Liu et al., 2013) instead of local informal exchanges.

4. Conclusion

In this short article we presented an integrated modelling perspective on provisioning EServ that poses equal emphasis on social and ecological dynamics. The implications of taking into account human flows within EServ assessments stand out because scientists could draw more informed conclusions on the sustainability of the EServ dynamics in coupled human-natural systems. In particular, the recognition of the role of human behavior and human flows is a prerequisite to optimize the benefits that society receives from nature without degrading it to the point (so called tipping points) where EServ can no longer be generated with the same ecological efficiency.

Past research has shown how system governance is key to achieve a sustainable use of natural resources. Thanks to the work of Ostrom (1990, 2009) scientists already know what the empirical conditions that lead to sustainable self-organized communities are. We presented a social-ecological governance compass that can help framing how individual behavior produces collective outcomes in terms of EServ management. The adoption of an agent-based perspective is functional to the identification of relevant social agents, their role and behaviors, and the interdependencies displayed in the network of EServ.

The case of food security in a rural community setting instantiates the role of key social interactions in optimizing the flow of benefits from nature to humans. These flows are enabled at the community level by the individuals' cooperative economic behavior (possessing a community level objective function) and by a differentiated approach to food production (facilitated by the openly sharing of knowledge about other EServ beneficiaries).

We argue that this study can provide valid insights that apply beyond local communities. Similar informal exchanges within social networks are booming under the radars globally, hampered by the economic crises and by the exponential growth of information and communication technologies.

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References

Anderman, T.L., Remans, R., Wood, S.A., DeRosa, K., DeFries, R.S., 2014. Synergies and tradeoffs between cash crop production and food security: a case study in rural Ghana. Food Security 6, 541–554.

Axelrod, R., Hamilton, W.D., 1981. The evolution of cooperation. Science, 211(4489), 1390–1396.

Bagstad, K.J., Semmens, D.J., Waage, S., Winthrop, R., 2013. A comparative assessment of decision-support tools for ecosystem services quantification and valuation. Ecosystem Services, 5, 27–39.

Balbi, S., Giupponi, C., 2010. Agent-based modelling of socio-ecosystems: a methodology for the analysis of adaptation to climate change. International Journal of Agent Technologies and Systems, 2, 17–38.

Barrett, C.B., 2010. Measuring food insecurity. Science, 327(5967), 825–828.

Berbés-Blázquez, M., González, J.A., Pascual, U., 2016. Towards an ecosystem services approach that addresses social power relations. Current Opinion in Environmental Sustainability, 19, 134–143.

Berkes, F., Colding, J., Folke, C., 2008. Navigating social-ecological systems: building resilience for complexity and change. Cambridge University Press.

Bennett, E.M., Cramer, W., Begossi, A., Cundill, G., Díaz, S., Egoh, B.N., Geijzendorffer, I.R., Krug, C.B., Lavorel, S., Lazos, E., others, 2015. Linking biodiversity, ecosystem services, and human well-being: three challenges for designing research for sustainability. Current Opinion in Environmental Sustainability, 14, 76–85.

Bonabeau, E., 2002. Agent-based modeling: Methods and techniques for simulating human systems. Proceedings of the National Academy of Sciences, 99, 7280–7287.

Burchi, F., De Muro, P., 2016. From food availability to nutritional capabilities: Advancing food security analysis. Food Policy, 60, 10-19.

Coase, R.H., 1960. The Problem of Social Cost. The Journal of Law and Economics, 3, 1–44.

Chinsinga, B, 2007. Hedging food security through winter cultivation: the agronomy of dimba cultivation in Malawi. Education Development Conference. Accessed online 13/06/2016 at http://www.eldis.org/vfile/upload/1/document/1106/Hedging%20Food%20Security%20through%20winter%20Cultivation.pdf.

Dobbie, S., Balbi, S., 2015. Design of an empirical agent-based model to explore rural household food security within a developing country context. Proceedings of the Social Simulation Conference (ESSA 2015), Springer Proceedings in Complexity, in press.

Dorward, A. and Kydd, J., 2004. The Malawi 2002 food crisis: the rural development challenge. The Journal of Modern African Studies, 42(03), 343–361.

Filatova, T., Verburg, P.H., Parker, D.C., Stannard, C.A., 2013. Spatial agent-based models for socio-ecological systems: challenges and prospects. Environmental modelling & software, 45, 1–7.

Gliessman, S., 2009. Editorial: A Framework for the Conversion to Food System Sustainability, Journal of Sustainable Agriculture, 33 (1).

Gómez-Baggethun, E., Naredo, J.M., 2015. In search of lost time: the rise and fall of limits to growth in international sustainability policy. Sustainability Science, 10(3), 385–395.

Grey, M., 2000. The industrial food stream and its alternatives in the United States: An introduction. Human Organization, 59(2), 143–150.

Hardin, G., 1968. The tragedy of the commons. Science, 162(3859), 1243–1248.

Kremen, C., Miles, A., 2012. Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. Ecology and Society, 17(4), 40.

Krutilla, J.V., 1967. Conservation reconsidered. The American Economic Review, 57(4), 777–786.

Lester, J.C., 1994. The evolution of the political compass (and why libertarianism is not right-wing). Journal of Social and Evolutionary Systems, 17, 231–241.

Liu, J., Hull, V., Batistella, M., DeFries, R., Dietz, T., Fu, F., Hertel, T.W., Izaurralde, R.C., Lambin, E.F., Li, S. and Martinelli, L.A., 2013. Framing sustainability in a telecoupled world. Ecology and Society, 18(2), 26.

MA (Millennium Ecosystem Assessment), 2005. Ecosystems and human well-being. Island press Washington, DC:

Maddox, W.S., Lilie, S.A., 1984. Beyond liberal and conservative: Reassessing the political spectrum. Cato Institute.

Nassl, M., Löffler, J., 2015. Ecosystem services in coupled social–ecological systems: Closing the cycle of service provision and societal feedback. Ambio, 44(8), 737–749.

Ostrom, E., 1990. Governing the commons. Cambridge University Press.

Ostrom, E., 2009. A general framework for analyzing sustainability of Social-Ecological Systems Science 325, 419.

Patel, R., 2009. Food sovereignty. The Journal of Peasant Studies, 36(3), 663–706.

Petrini, C., 2003. Slow food: The case for taste. Columbia University Press.

Pollan, M., 2001. The botany of desire: a plant's-eye view of the world. Random House Trade Paperbacks.

Poppy, G.M., Chiotha, S., Eigenbrod, F., Harvey, C.A., Honzák, M., Hudson, M.D., Jarvis, A., Madise, N.J., Schreckenberg, K., Shackleton, C.M., others, 2014. Food security in a perfect storm: using the ecosystem services framework to increase understanding. Philosophical Transactions of the Royal Society of London B: Biological Sciences 369, 20120288.

QUINTESSENCE Consortium, 2016. Networking our way to better ecosystem service provision. Trends in Ecology & Evolution, 2034: 105–115.

Rausser, G., Zilberman, D., Kahn, G., 2015. An alternative paradigm for food production, distribution, and consumption: A noneconomist's perspective. Annual Review of Resource Economics, 7, 309–331.

Raymond, C.M., Bieling, C., Fagerholm, N., Martin-Lopez, B., Plieninger, T., 2016. The farmer as a landscape steward: Comparing local understandings of landscape stewardship, landscape values, and land management actions. Ambio, 45(2), 173–184.

Sagoff, M., 2008. On the economic value of ecosystem services. Environmental Values, 17(2), 239–257.

Sahley, C., Groelsema, B., Marchione, T., Nelson, D., 2005. The governance dimensions of food security in Malawi, vol. 20. USAID.

Sen, A., 1983. Development: Which way now? The Economic Journal, 93(372), 745–762.

TEEB, 2010. The Economics of Ecosystems and Biodiversity: ecological and economic foundations. Earthscan, London.

Verhulst, N., Govaerts, B., Verachtert, E., Castellanos-Navarrete, A., Mezzalama, M., Wall, P., Deckers, J., Sayre, K.D., 2010. Conservation agriculture, improving soil quality for sustainable production systems. Advances in soil science: food security and soil quality. CRC Press, Boca Raton 137–208.

Villa, F., Bagstad, K.J., Voigt, B., Johnson, G.W., Portela, R., Honzák, M., Batker, D., 2014. A methodology for adaptable and robust ecosystem services assessment. PloS one, 9, 91001.

Witkin, H. A., Price-williams, D., Bertini, M., Christiansen, B., Oltman, P. K., Ramirez, M., & Meel, J. V. (1974). Social conformity and psychological differentiation. International Journal of Psychology, 9(1), 11–29.

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