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COMMENTARY

Socio-ecological research and the transition toward sustainable agriculture

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It is well-established that modern agricultural practices contribute to the deterioration of the environment and negatively impact human health (Reganold & Wachter, 2016; Rockström et al., 2017). Studies have therefore aimed at strengthening both the scientific base for, as well as promoting, practical alternatives that will reduce the environmental impact of conventional agricultural practices (Godfray et al., 2010). In this commentary, we draw attention to the benefits of a transdisciplinary, socio-ecological research framework for studying the challenges associated to sustainable practices in agriculture. Such research has taken an integrative approach to environmental science, emphasizing components in both biological and social spheres, as well as their interconnectedness (Collins et al., 2011; Liu et al., 2007). More specifically, agro-ecology advocates synergies between three distinct systems: the environment, food production and the socio-economic context. Sustainable intensification promotes the understanding that crop yields can be significantly increased without causing further environmental deterioration (Pretty, Toulmin, & Williams, 2011). For both of these approaches, primary means to achieving 'sustainable agriculture' include the integration of local, practical knowledge that deals with the needs and concerns of farmers in conjunction with iterative testing of the validity of ecological solutions to environmental challenges (Gliessman, 2014; Pretty & Bharucha, 2014).

It has already been demonstrated, however, that major hindrances to the uptake of more sustainable agricultural practices by farmers – such as the Integrated Pest Management (IPM) method – include farmers' motivations, knowledge, attitudes and risk perceptions (e.g. Meijer, Catacutan, Ajayi, Sileshi, & Nieuwenhuis, 2015). On the one hand, farmers are reluctant to make a transition because of (perceived or real) increased economic risk, including the cost of materials and equipment, the uncertainty of profitability and potential reduction in yields (Grover & Gruver, 2017; Rodriguez, Molnar, Fazio, Sydnor, & Lowe, 2009). Furthermore, scientists, and especially conservation ecologists, are often unsuccessful in expressing their research results in ways that are meaningful to their target-groups (Groffman et al., 2010). Our suggestion here, therefore, is that interdisciplinary, socio-ecological research can assist in overcoming such uncertainties and risk perceptions, and thus contribute to a transition toward more sustainable agriculture.

Our brief reflection here is based on our ongoing study of the interrelations between biodiversity and a transition toward sustainable practices in wine-grape growing (Shapira et al., 2017). Viticulture offers greater incentives, but also unique challenges, for sustainable agriculture compared with other food-producing agricultural activities, because wine is considered a luxury good. In addition, vineyard growers are often subjected to industrial wineries' requirements. Wineries are usually equipped with business plans and branding ambitions, permitting the farmers little independence in their choice of growing practices.

In our case, a winery interested in rebranding their product as environmentally sustainable turned to a team of ecologists to suggest and examine strategies for increasing biodiversity in vineyards. The farmers in the study were asked by their winery's agronomist not to use herbicides between rows in one of their vineyards and instead let the local herbaceous vegetation

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grow in order to function as cover-crops. The weeds were mechanically trimmed as needed to prevent competition for water with the grapevines and to allow the growers easy access to the rows. Each farmer was requested to apply herbicides for weed management (i.e. use the conventional practice) in a second, matched, vineyard. The hypothesis behind this study was that the interstitial vegetation, planted or natural, between vineyard rows would provide habitat for beneficial insects, contribute to greater biodiversity and protect against soil erosion as compared with the herbicide-treated vineyards. This alternative practice was also expected to reduce the growers' expenses for herbicides and, potentially, for insecticides.

The researchers, however, were cognizant of the fact that there is often a significant gap between conservation goals, scientific knowledge, farmers' perceptions, and the winery's interest, all of which hinders the uptake of proposed ecologically oriented practices. Thus, in order to examine the barriers preventing the adoption of the recommended sustainable practices and to develop policy recommendations, a social component was added to the research that featured direct communication with the farmers who took part in the ecological experiment. The research team was expanded to include environmental policy researchers and additional research components were added, including a policy analysis and integration of stakeholder perceptions and insights into the analysis. In other words, the researchers adopted a *socio-ecological* approach, which extended beyond the implementation and monitoring of agro-ecological practices and their implications on biodiversity and agricultural productivity.

Important insights were quick in coming, offering both practical and theoretical insights. During the course of the study, for example, one of the farmers noted that he would have voluntarily reduced his use of chemical herbicides and use biological means instead, only if he knew for certain that both practices were equally effective. Another farmer stressed her suspicion that due to the research 'it was the experimental plot with the cover-crops in the vineyard that was terribly affected by mildew, in fact the worst attack the vineyard has ever experienced' (Farmers, personal communication, 7 July 2016).

A considerable amount of research has focused on risk communication and how best to inform farmers about potentially risky practices. Not surprisingly, most of the studies pertain to the need to communicate the risks of pesticide use to farmers, farm workers, nearby residents and consumers alike (e.g. Ríos-González, Jansen, & Sánchez-Pérez, 2013). Yet, while a transition to more sustainable agricultural practices and reduction in pesticide use may decrease health risks for the general public, and for farm workers in particular, farmers' economic risk perceptions are far from alleviated. The results of this ongoing study suggest that communication of risk is therefore also essential with regard to risks associated with environmental and health-friendly practices. This is especially needed during the period of ecological experimentation. If agricultural sustainability is the goal, then multiple forms of 'risks' should be taken into account, including the potentially adverse impacts of suggested ecological practices.

Another advantage in adopting a socio-ecological approach to research is the opportunity to facilitate 'reflexive learning' (Daedlow et al., 2016; Hadorn, Bradley, Pohl, Rist, & Wiesmann, 2006) and to enhance trust utilizing different configurations of social capital (Pretty & Bharucha, 2014). In particular, this approach can help highlight and bridge the gap between the ecologists' normative assumptions and the empirical findings of their study. For instance, ecologists' assumption that managing for biodiversity conservation presents a win-win strategy often does not resonate with the concerns of farmers, and more-so when the experimental results are ambiguous. Further, the farmers are often expected to continue working under conditions of uncertainty while the ecologists test scientific assumptions. In a socio-ecological research framework, the scientists gain a better understanding of stakeholder concerns and ideally learn how to better communicate science, facts and uncertainties. The farmers may benefit from access to innovative scientific knowledge and the opportunity to alleviate their concerns. In this way, the participatory approach of socio-ecological research facilitates a two-way learning process between scientists and farmers that includes such crucial issues as risk communication, ecological values and trade-offs.

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