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## **Towards a Psychology of the Food-Energy-Water Nexus: Costs and Opportunities**

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We would like to extend our gratitude to the Society for the Psychological Study of Social Issues (SPSSI), the Society of Australasian Social Psychologists (SASP), and the University of Pennsylvania for hosting the Psychology of Sustainable Consumption Small Group Meeting. Our call to action for psychology researchers to become involved in FEW nexus research emerged from a FEW nexus workshop at this meeting which was co-led by the first two authors of this article.

*Scholars, government scientific research institutions, and public policy-making entities are increasingly focusing on environmental issues from a food-energy-water (FEW) nexus perspective. This nexus represents the interconnection of these three systems, which are essential to human life. The FEW nexus is inherently and inescapably interdisciplinary. However, to date, there have been relatively few academic contributions to understanding the nexus from the social sciences, particularly from psychology. In this article, we suggest an extended framing of the nexus (food-energy-water x human) to explicitly recognize how human actions in the form of both consumption practices and population size and distribution impact the FEW nexus. We outline important contributions that psychology researchers could make in FEW nexus focused research teams. In doing so, we acknowledge difficulties and potential risks for psychology researchers engaging in FEW nexus based research, but suggest that, while such difficulties can create barriers, they can also present opportunities for psychologists.*

### **Towards a Psychology of the Food-Energy-Water Nexus: Costs and Opportunities**

The food-energy-water (FEW) nexus is central to the survival of human life on this planet. As such, an understanding of this nexus is fundamental for effective sustainability research.<sup>1</sup> The FEW nexus refers to the intrinsic interconnectedness of food, energy, and water systems—a critical connection that shapes the way each dimension can be used, maintained, and adapted, and the consequences for doing so. Production in one dimension of the nexus typically involves affecting the other two dimensions. Sometimes—based on conventional, modern industrialized FEW systems—this aspect of production comes with trade-offs. Examples of such trade-offs can be found in concerns about the disruption of farmland or pollution of water sources as a result of energy production (Wang, Lim, & Ouyang, 2017).

Past research on the FEW nexus has mainly occurred within the natural sciences and engineering while the social sciences and accompanying human dimensions research has largely been absent (Hannibal & Portney, 2019). The importance of considering the human dimensions of the FEW nexus is twofold. First, management of the trade-offs between the three nexus systems often come at a cost to human well-being, particularly for the world's poor (McShane et al., 2011). Second, increasing consumption demands, of a growing population that is adopting a highly-resource-intensive lifestyle, are stretching humanity's existing ecological systems to a breaking point via its impact not just on food, energy, and

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<sup>1</sup>Sustainability can be defined as meeting “the needs of the present without compromising the ability of future generations to meet their own needs” (United Nations Brundtland Report, 1987). Efforts to reach these needs are often considered as having environmental, social, and economic impacts which themselves, affect each other.

water systems but on the extended impacts of each system on other systems (Das & Cabeza, 2018; Martinez-Hernandez & Samsatli, 2017).

The expansive nature of the nexus makes it the perfect stage for an interdisciplinary approach to research and intervention. In line with this approach, Abraham (2018) suggests that a broad “systems based approach is required to gain a better understanding of how these resources can be used and managed to achieve a more sustainable world” (p.20). Contrary to this suggestion, research into nexus issues has largely been siloed into each individual domain, with little consideration given to the nexus as a whole. However, research into the FEW nexus has gained traction in recent years, with specific support from governmental scientific funding bodies in the United States such as the National Science Foundation and the United States Department of Agriculture (NSF, n.d.), public policy making entities such as the European Union (Nexus Programme, n.d.), and a targeted special section in the journal *Environmental Progress and Sustainable Energy* (Abraham, 2018). Thus, the FEW nexus is emerging as an important focus for the future of sustainability research, and one that may be fundamental to solving some of the world’s most pressing environmental and sustainable development challenges (see Box 1 for an example of FEW research in action).

**Box 1. Research in Action: A FEW example**

Researchers at Johns Hopkins University, Arizona State University, and the University of Florida are conducting innovative research linking quantitative and qualitative methods to reduce resource use and waste in the seafood supply chain. Through focusing on the (sea)food, energy, and water nexus, the research team is taking a systems approach to understanding resource inefficiencies in producing and harvesting seafood as well as the factors shaping waste across the supply chain and in the household. Psychological expertise, among multiple other types, is being used to understand the factors related to food waste as well as to test the feasibility of interventions aimed at reducing energy, water, and food waste. In a novel approach, results from a nationwide seafood waste diary study are being integrated into a lifecycle analysis to better understand the amount of embedded energy and water wasted in U.S. households.

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Although there is much potential for psychology researchers to contribute to nexus research, they are only just beginning to engage with the FEW nexus. In this perspective piece, we issue a call to action for psychology researchers to become involved in FEW nexus research. This call emerges from a FEW nexus workshop

co-led by the first two authors at the Psychology of Sustainable Consumption Small Group Meeting, hosted by the Society for the Psychological Study of Social Issues (SPSSI), the Society of Australasian Social Psychologists (SASP), and the University of Pennsylvania in Philadelphia, PA in May 2018. We examine potential barriers to participation for psychology researchers in this topic area and the opportunities that researchers have to play a critical role in the study of the FEW nexus.

### **Nexus Research**

The nexus is inherently and inescapably interdisciplinary, requiring input from both the natural and social sciences to resolve its myriad issues. However, as of yet, contributions from the social sciences are largely absent from the nexus conversation. We are aware of a few exceptions. There is a growing literature on “nexus governance” that investigates collaborations across government agencies, organizations, and stakeholder groups applied to issues such as wastewater reuse (Kurian et al., 2019) and hydropower on shared rivers (Dombrowsky & Hensengerth, 2018), as well as analyses of nexus governance in specific cities (Daher et al., 2019; White, Hubacek, Feng, Sun, & Meng, 2018). A focus on governance issues is important as laws and policies are often implemented when decisions related to food, energy, and water services are made (Kurian et al., 2019).

There are also a few examples of FEW nexus research that aligns with psychologists’ expertise. Some research focuses on psychological predictors of policy support. Bullock and Bowman (2018) found that knowledge about nexus issues as well as broad concern for the environment was positively associated with citizens’ support for policy tools aimed at managing food, energy, and water resources. Similarly, Portney et al. (2018) assessed awareness of the FEW nexus in the American public and how that awareness was linked to policy support. They found that people were least aware of the energy-food nexus and most aware of the water-energy nexus. Furthermore, awareness of any one nexus was linked to awareness of another nexus, for which they suggest the existence of a latent “nexus cognition construct.” This construct appears to be related to support of policies related to nexus elements (e.g., reducing the reliance on energy use for water). Building on that study, Hannibal and Portney (2019) examined predictors of public awareness of the FEW nexus and found that concern about food waste was correlated with awareness of the food-water nexus and awareness of water waste was correlated with water-energy nexus. They concluded that concerns about waste seemed to play a large part in influencing some people to make a connection among food, energy, and water.

Other work has focused on individual pro-environmental spillover, which includes attention to spillover among food, water, and energy related behaviors. Notably, research in this area indicates that positive spillover is more likely to

occur within behavioral domains than across behavioral domains (Nash et al., 2017; Truelove, Carricio, Weber, Raimi & Vandenberg, 2014). Sometimes these domains are linked to the FEW nexus (e.g., energy and waste, with waste including food waste) but there is no explicit reference to the FEW nexus (Sintov, Geislar, & Lee, 2017). We believe a lack of focus on the nexus is representative of psychology research in general. We suggest a number of potential reasons for this in the following section.

### **Potential Barriers to Participation for Psychology Researchers**

A first potential barrier is the tendency of psychology research to employ traditional experimental designs that do not foster research on systems. Research to date primarily isolates predictors of particular actions or class of actions focusing on elements of the FEW nexus rather than, for example, relations among its elements. Researchers' mental models of environmentally relevant behaviors may be in terms of particular problem domains that have been the traditional approach to understanding environmental problems. For instance, mental models about problems such as water or air pollution and species extinction, and correspondingly, solutions such as waste management, energy and biodiversity conservation, and the ethical treatment of animals can lack a systems focus. This approach has yielded psychological research focusing on individual behavioral actions such as household recycling and electricity usage, transportation choices, or collective action such as protests.

A related problem, and second barrier, is that the thoughts, feelings, and behaviors of people are the center of attention for (most) psychologists, and thus, psychological questions emerge from this perspective. An exception, as noted above, is research on behavioral spillover that focuses on relations among behaviors. Yet, even within this research, there is a greater focus on individual level predictors and explanations for when and why spillover occurs rather than understanding relations among different behavioral types (Truelove, Carrico, Weber, Raimi, & Vandenberg, 2014). Thus, the research questions that emerge from the FEW nexus do not obviously intersect with the research questions that gain psychologists' attention. Further, in psychology, a behavior such as resource use is generally treated as an *outcome* of a series of individual or social psychological processes. In focusing on behavior as an outcome, rather than a predictor, this research often neglects the consequences of the behavior, in this case resource use, on a variety of other behaviors and systems. As a result of this focus, the ways in which resource use might be intertwined with and have (system-level) implications for the use of different types of resources does not fit easily into our standard, simple (psychological) cause and (behavioral) effect model.

Third, our methods, statistics, and way of thinking and approaching problems can be inherently linear and reductionist. Generally speaking, as psychologists we

are trained to think about the individual, not the system, as a unit of analysis. In doing so, we are not trained to think about system interdependencies. Psychological research tends to focus on linear relations, with a strong emphasis on studying mediational pathways to identify psychological mechanisms that explain relations between situations or people and a behavioral outcome. We recognize that this disciplinary mindset is also present in other social sciences and therefore the resulting methods, theories, assumptions, and statistics used can create a barrier and may limit the application to nexus issues. Examples of exceptions include using computers (microworlds) to understand natural resource decision-making (Chen & Bell, 2016), using social network analysis to explore how social network structure is related to pro-environmental behavior (Geiger, Swim, & Glenna, 2019), and understanding different tendencies to think in terms of systems (Ballew, Goldberg, Rosenthal, Gustafson, & Leiserowitz, 2019). Understanding what can be gained by system approaches to studying pro-environmental actions could generalize to understanding what can be beneficial about studying the FEW nexus, perhaps particularly if one integrates human systems within the FEW nexus.

A fourth potential barrier for some psychology researchers' engagement with the FEW nexus relates to the publication of findings. Due to the diverse disciplinary inputs outside of psychology necessary to study FEW issues, it is difficult to produce a publishable output suitable for mainstream psychology journals. This problem is obviously not unique to FEW issues; it can also be applied to social scientists conducting interdisciplinary work in general (Schuitema & Sintov, 2017). The inability to publish in mainstream psychology journals can come at a cost to early career psychology researchers working within universities, as publishing in disciplinary journals may be favored by their departments.

A fifth reason that some psychologists may shy away from FEW nexus research stems from the aforementioned fact that such work, by virtue of being inescapably interdisciplinary in nature, necessitates working as part of an interdisciplinary team. Such teams can represent challenging environments and may include career costs (Al Sayah, Szafran, Robertson, Bell, & Williams, 2014; Pischke et al., 2017, Schuitema & Sintov, 2017). For example, working as the sole social scientist on a project can be challenging if there is an expectation that one (as a psychologist) should be able to provide expertise across the entirety of the social scientific domain. Moreover, if the critical role for the content of psychological research is not recognized and defined within the interdisciplinary team, psychologists may find that they are (instead) thrust into the role of managing the sometimes complex interpersonal and intergroup dynamics that can be evident within interdisciplinary teams. This role can be frustrating if it comes at the expense of psychologists' actual academic expertise as it relates to the project's object(s) of investigation, their expertise being overlooked or ignored as a result. However, as Saber and Silka (in press) demonstrate, despite these initial costs, the insights gained from such interdisciplinary collaboration are invaluable for

effectively addressing and resolving problems within all domains of sustainability research.

A final reason that psychology researchers may avoid the FEW nexus is that some of the potential solutions that have been suggested to resolve issues within the nexus may be seen as controversial or polarizing. Examples include issues and potential solutions involving a need to reduce worldwide human population size and/or density, as well as a need to change types and scales of consumption systems. Critically, the number of people on the planet (and how and where they live) impacts the FEW nexus. Population is, itself, a deeply sensitive topic. Decisions about when and how many children to have is defined as a basic human right (United Nations, n.d.). Attempts to affect these decisions on a policy level can be easily abused (Coole, 2013) and efforts to reduce population to decrease greenhouse gas emissions often targets developing countries while ignoring developed countries (Gaard, 2015). As a result, it is difficult to find funding to support this type of work, although some funding bodies have provided support in the past (Bridge Collaborative, n.d., USAID, n.d.). FEW nexus research offers the possibility of shining a spotlight on critical human consumption systems and behaviors.

### **What Could Psychology Offer to the Study of the Nexus?**

One of the fundamental properties of FEW nexus systems is that human activity impacts each of the systems. For example, people engage in various activities that consume energy, such as supplying water to particular locations, often for the production of food. Some of this food might then end up as food waste, which, in turn, can be used to create energy that feeds back into the system. Moreover, these same systems also impact human abilities to engage in all manner of crucial and life-enhancing activities, such as providing ourselves with sustenance, hydration, shelter, mobility, and electronic modes of communication. Therefore, the discipline of psychology seems ideally placed to examine human psychological and behavioral drivers of the bidirectional relationships involved in the FEW nexus.

Two of the most critical sides of the human dimension of the nexus relate to (1) the number of human beings that are engaging with these systems and (2) the rate and scale at which they are doing so. Indeed, one could argue that the FEW nexus might be better called the food-energy-water x human nexus (FEWxH), to take into account the central role that human populations and behaviors have in altering ecological and human-created systems on which life depends. Emphasizing this central role of human activity invites two streams of inter-related psychological and interdisciplinary research: (1) human activity depleting or damaging resources; and more importantly, (2) identifying and amplifying positively deviant human activity that conserves and strengthens ecological systems (Abrash Walton, 2018). It is notable that while demographers spend a great deal of time

studying population (growth) in a descriptive fashion, the psychology of population (growth), and its implications for consumption, is a topic that deserves, but has not yet received much attention within psychology (Clayton et al., 2017; Swim, Clayton, & Howard, 2011; Oskamp, 2000). As such, a focus on questions of sustainable consumption taken in the context of population growth represents a prime area of research for psychologists that would appear to hold great potential utility for thinking about the FEWxH nexus. Further, the current dominant linear economy of human consumption from systems of extraction, production, distribution, use, and waste all involve food, energy, and water systems. Even sustainable consumption practices that could involve a circular economy where waste is returned to the system, would still involve effects on food, energy, and water systems and have compounding effects based upon the interrelations of these systems.

Indeed, widening one's thinking and levels of analysis as a psychologist to a broader, FEWx H nexus level has the potential to open up new and novel types of research questions and agendas, and represents a gain for our discipline. For example, psychologists typically examine people's willingness to reduce consumption of specific food, energy, and water resources voluntarily, or their levels of support for policies to enforce such outcomes (Schmitt, Neufeld, Mackay, & Dys-Steenbergen, in press). However, it is rare in such work for trade-offs between support of behavioral/policy changes in different parts of the nexus to be examined.

To illustrate this point, consider the situation of industrialized populations living in relatively arid and hot environments. Here, the scarcity of water produces difficult potential trade-offs across the nexus, especially if carbon emission reduction targets are also being pursued. The bulk of psychological research in such contexts has focused on how to get residents to use less water in their homes and gardens, or levels of support for restrictions on such activities (Russell & Fielding, 2010). However, a consideration of the wider resource nexus draws into focus the extent to which individual behaviors and institutional policies around domestic water consumption should be considered in terms of their implications for, and inter-relationships with, the supply and demand for food and energy.

Government agencies in the developed world will often respond to (predicted) domestic water shortages by installing infrastructure such as desalination plants, which consume large amounts of energy. Under a scenario where "carbon budgets" are taken seriously, this should (in time) reduce the energy resources available for other activities, such as air-conditioning. Residents' psychology around the thermal comfort of their homes, may, in turn, be greatly influenced by other activities highly related to their water consumption, such as desires for swimming pools or forms of (often nonindigenous and water-thirsty) garden landscaping that they regard as psychologically cooling (Larsen et al., 2009). Furthermore, the



extraction of water to meet such domestic appetites is ultimately in conflict with the irrigation needs of the agricultural industries that seek to meet the various dietary expectations of consumers (Grafton et al., 2013). Thus, one begins to see how the psychology of resource use and policy support in industrialized arid environments becomes more than simply the sum of its water, energy and food psycho-behavioral parts.

In the above scenario, psychologists would benefit from trying to investigate and understand the psychology of “arid living” in a more holistic way that takes seriously the interconnected nexus of both the involved natural resources themselves and people’s everyday relationships with them and their consumption. In this regard, such psychological investigations could benefit from a cross-fertilization of ideas from the application of social practice theory (e.g., Shove, Pantzar, & Watson, 2012) derived from sociology. This theoretical approach treats social practices themselves (e.g., lawn watering) as the unit of analysis, in contrast to psychology’s usual focus on the psychology of the individual “carriers” of these practices. In so doing it seeks to examine the ways in which consumptive practices emerge and evolve through the commingling of the material (e.g., lawn reticulation systems), procedural (authority-stipulated watering rules) and meaning (e.g., notions of “green” and “cool” landscapes) elements of social practices. An approachable guide for psychologists can be found in Kurz, Gardner, Verplanken, and Abraham (2015).

Furthermore, it is rather uncommon for there to be any departure from the “business as usual” assumptions of human population growth underpinning the rate and scale of ecological consumption. Deliberations and policy formulation surrounding resource provision decisions in both local and global contexts typically start from a predicted future level of consumption that assumes continued population growth (Bongaarts & O’Neill, 2018; Bridgeman, 2017). As psychologists, perhaps especially those from WEIRD—Western, educated, industrialized, rich, democratic—countries (Henrich, Heine, & Norenzayan, 2010), we rarely unpack the psychological foundations of such assumptions, which presumably include a primacy of the individual right to produce as many children as one desires and to (continue to) reside in a geographical area of one’s choosing. However, there can be problematic relations between such choices and critical human needs such as access to adequate quantities and qualities of food, air and water, shelter, and transportation. Thus, one could envisage a point in the future where the study of psychological trade-offs between such rights and values could become a key (if not likely highly controversial) foci of psychological research. The reductionism that occurs in traditional psychological research misses these various dynamic associations among food, energy, water and humans due to consumption practices and population growth and dispersion, and could be ameliorated through a FEWxH perspective.

Our work on the FEWxH nexus will not be meaningful or have the appropriate scale if conducted alone. Psychologists could contribute through being part of interdisciplinary teams of researchers that include the natural sciences, engineering, and also the arts and humanities. For example, a psychologist could work on a team to layer social science research questions and methodologies with lifecycle analysis of a system or product. This work would help us understand not just which behaviors are best for the environment and society, but also how to move people to change their behavior associated with the most impactful actions at the FEWxH nexus (see Box 1). The results of a project like that could then also be used as the subject of an art installation at a well-known art museum and thus create a different way of understanding the FEWxH nexus, similar to how visual art related to climate issues is being used as a way to understand and communicate climate change (Roosen, Klöckner, & Swim, 2018).

### **How to Think and Act Like a Nexus Researcher (A Road Map)**

Here we offer tips for the curious psychological researcher about how to approach research from a nexus point of view. This list is not meant to be exhaustive, but merely a starting point and a catalyst for idea generation.

1. Consider a research agenda that seeks to identify positively deviant human behavior that contributes to transforming consumption systems and improving ecological outcomes within the FEWxH nexus.
2. Identify what can be applied from understanding the values, norms, and behaviors underlying this positive deviance.
3. If wishing to research behavior related to consumption of a particular resource, consider whether such behaviors may also be psychologically, behaviorally, or politically bound up with consumption of other resources.
4. Seek out interdisciplinary collaborators and/or practitioners who can help provide insights into FEW systems and their effects on each other (or seek out whom you can help to bring a psychological dimension to their system-level work).
5. Think about the policy implications of your research and possible trade-offs or unintentional consequences of policies. Are there any potential connections to other domains within the nexus? Are there opportunities for taking a nexus governance approach in future research?

## Conclusion

Psychology has much to offer in the study of the FEWxH nexus, but there also exists a range of barriers to researchers. We use these concluding remarks to issue a call to action for psychologists, and other social scientists, to become more involved in FEWxH nexus research that focuses on the critical dimensions of consumption and population. We suggest an extended framing of the nexus to explicitly recognize how human actions in the form of both consumption practices and population size and distribution impact the FEW nexus. This framing includes attending to patterns and predictors of human behavior, institutions, public policy, and other social practices that have created the FEWxH issues that we are trying to solve. Furthermore, sustainability requires expertise about personal drivers such as attitudes and beliefs, group membership, and self-efficacy as well as organizational systems that shape consumption behavior (Abrash Walton, in press; Harmann & Reese, in press; Kurz, Prosser, Rabinovich, & O'Neill, in press; Schmitt et al., in press; Tugwell, Robinson, Grimshaw, & Santesso, 2006). The field of psychology is ideally focused to add input and guide policies aimed at introducing behavioral sustainability solutions within the FEWxH nexus.

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