To what extent should we ensure the explicit inclusion of water quality within the WEF nexus? Discussion of “Water quality: the missing dimension of water in the water–energy–food nexus”

Arnbjerg-Nielsen, Karsten; Gain, Animesh K.; Keskinen, Marko; Varis, Olli; McKnight, Ursula S.

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Authors:

Karsten Arnbjerg-Nielsen[1], Animesh K. Gain[2,3], Marko Keskinen[4], Olli Varis[4], Ursula S. McKnight[1,5]

1 Department of Environmental Engineering, Technical University of Denmark, Lyngby, Denmark

2 Department of Urban Studies and Planning, Massachusetts Institute of Technology, Cambridge, United States

3 Ca' Foscari University of Venice, Department of Economics, Venice, Italy

4 Water and Development Research Group, Department of Built Environment, Aalto University, Finland

5 Swedish Meteorological and Hydrological Institute, Norrköping, Sweden

ORCID:

KA-N: 0000-0002-6221-9505

AKG: 0000-0003-3814-693X

MK: 0000-0001-5236-2327

OV: 0000-0001-9231-4549

USM: 0000-0001-8363-8672

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Abstract

We congratulate Heal et al. (2021) for initiating an important discussion on how to broaden the scope of the Water-Energy-Food nexus. We agree that more explicit inclusion of water quality into the nexus is an important step forward. At the same time water quality is itself an indicator of e.g. ecosystem services and biodiversity, and improvement of water quality comes with a cost in terms of resource consumption that is typically not included in models studying the Water-Energy-Food nexus. We already see hesitation in using the nexus for policy development, and further complexity may be a further barrier to its practical implementation. So, while the consideration of water quality is indeed important for the nexus, it also suggests that perhaps it is necessary to consider more local contexts than striving for one global framing for analysis of the Water-Energy-Food nexus.

Highlights

- Water quality should indeed be an integral part of Water-Energy-Food nexus analyses
- WEF has yet to be adopted as a framework for decision-making
- Focussing on implementation on macro levels may enhance uptake of nexus analyses

Introduction

The paper by Heal et al. (2021) raises the important issue of the need to consider water quality more explicitly in relation to the Water-Energy-Food (WEF) nexus. We fundamentally agree with the authors that this aspect deserves more attention, for two key reasons: the various implications that the nexus has for water quality (and vice versa), and the fact that most nexus studies nevertheless consider water quantity alone. This is the situation even though the WEF concept was originally conceived as encompassing water quality as well (Hoff, 2011).

There may, however, be a potential pitfall in the sense that many scientists as well as practitioners easily claim that their domain is particularly important to any problem definition, leading to an increasing number of themes to be considered. Essentially this may overly complicate planning and decision-making, and in the end, such an all-encompassing policy is likely to become non-implementable. In this regard, we note similar considerations on potential nexus extensions on other important themes such as ecosystems (De Strasser et al., 2016), soils (Lal et al., 2017), forests (Melo et al., 2020) and livelihoods (Biggs et al., 2015), as well as broader aspects related to e.g. politics (Allouche et al., 2015) and decision making (Gallagher et al., 2020).

These contributions show that the WEF nexus is gaining momentum as a much-needed framework for balancing three major interlinked resources for human prosperity. However, the continuous debate around the scope of the nexus is also a reminder about its potential limitations and suggests that the framework has not yet matured to a level where it is ready to be adopted as a standardized framework. In this context we agree with Heal et al. (2021) that water quality should be regarded as a fundamental component of the WEF nexus, inseparable from water quantity.

Below we touch upon a few points that we believe are highly relevant to include for better framing and making operational water quality in the context of WEF. We suggest that these points should be considered in the further development of the WEF Nexus framework – in particular when including water quality, but also in its original framing.

Modelling concepts of the WEF nexus with and without water quality

Heal et al. (2021) discuss existing WEF models under the implicit assumption that they agree on most of the concepts in their modelling approach. However, this may not be the case. Payet-Burin (2021) compares eight recent WEF models published and maintained by different institutions. While they all aim to provide input to policy development, none of the models agree on any of the 13 components on which he compares the models (e.g. data sources, sub-models, time step and calibration). The only proxy for water quality was that some of the models considered requirements for minimum water quantity flows, indirectly proving the point by Heal et al. (2021). Hence the implementation may be jeopardized simply because the concepts of existing WEF models differ substantially.

Similarly, there is a wide diversity of ways on how water quality is – and could be – considered as a part of the WEF nexus. The organization across an array of scales and with regards to their relevance in bi-directional relations between the three components of the nexus suggested by Heal et al. (2021) helps unifying the approaches for implementation. They condense this information in their Fig. 1 and continue with a reflection of future priorities for better inclusion of water quality in WEF. This is highly appreciated, and we also maintain that certain focusing and categorization is vital to help concentrate on the essentials of water quality.

As an example, when agriculture (for food or energy production) is in question, four types of water quality seem particularly relevant to consider. The first type is elevated leaching of nutrients, primarily nitrogen and phosphorus, and their impact on biological production, leading usually to eutrophication. Second, and partly related, is enhanced erosion and the subsequent changes in sediment (suspended solids and nutrient) content of a waterbody. Third, in arid areas, increased salinity is a typical issue. Fourth, the leaching of anthropogenic chemicals, e.g. pesticides and other chemical and biological compounds, the latter particularly when livestock, aquaculture or wastewater irrigation is in question, but could also include contaminated sites in mixed land-use catchments. Depending on the context, it may be relevant to model some or all of these interactions in an enhanced WEF framework including water quality.

Water quality as a surrogate for ecosystem services, biodiversity, and sustainability

Heal et al. (2021) mention numerous examples where water quality is key to ensuring that the objectives for energy and food can be met. The authors also clearly demonstrate that focusing on water quantity will not be sufficient to meet the water objectives within WEF; consequently, in many cases, water quality will need to become an integral part of WEF nexus analyses. We agree with the statement by the authors, but note that the presented water quality examples come solely from an ecosystem-services (ESS) perspective, triggered possibly by the human-centric nature of the WEF framework. This focus on setting standards based on impact of human needs may lead to a lack of awareness of the equally important aspect of ensuring healthy ecosystems.

Moreover, it has become clear that improvements in ESS and human health are intrinsically linked to improved biodiversity, through recognizing the connectivity among the social, ecological and technical domains (McPhearson et al., 2021) of the WEF nexus. For example, increased stream temperature, stemming from e.g. wastewater releases, may impact fish populations. The ESS under consideration here could be both in terms of food, related to fish survival, as well as other services related to e.g. recreation (fishing) and improving human well-being. Recognition of these types of competing needs is critical, where improvements to and inclusion of water quality in action plans is now seen in fact as critical for ensuring a sustainable transformation in line with the UN Sustainable Development Goals (SDG) (Tickner et al., 2020).

The concerns about anthropogenic pressures to the environment, such as climate change, land-use change and urbanization, have triggered new regulations including the need for sound ecotoxicological risk assessment approaches (Artigas et al., 2012). However, they still seem to fail to properly account for the presence of chemical pollution (e.g. Posthuma et al., 2020) also within a multiple stressor context (e.g. Birk et al., 2020). This is evident, also based on the numerous cases illustrated by Heal et al. (2021), where water quality can be seen as the dominant issue at stake, depending on the local and regional context as well as the relevant spatio-temporal scale. Examples in the paper range from simple indicators such as water temperature and salinity to the many hundreds of compounds emitted from urban areas in highly varying concentrations. Although progress is being made in quantifying chemical impacts from urban sources (e.g. Brudler et al., 2019), the lack of *a priori* knowledge of which compounds to focus on remains a key concern. Moreover, the combined impacts of the many compounds are simply largely unknown and/or not captured by the traditional ecological indicators currently in use (Sonne et al., 2018). Even for compounds where the impacts may be known, our inability to quantify the underlying forces (causal relationships) prevents us from defining actions with confidence. As such, the inclusion of water quality seems to partly reframe the WEF concept from the narrower focus of providing basic human needs in an optimal manner to the broader aspects related to the concepts not only of ESS, but also that of both aquatic and terrestrial ecosystem health and more generally, the three pillars of sustainability.

Heal et al. (2021) explicitly state that we have entered the era of the Anthropocene. In line with this thought it is important to also consider the concept of planetary boundaries explicitly when considering water quality, since both biochemical flows and biosphere integrity is related to water quality (Steffen et al., 2015). While the human needs addressed in the WEF nexus require a consideration of more generic resource use and allocation, the concept of planetary boundaries – with its emphasis on long-term sustainability and Earth System balance– reminds us that current considerations of the WEF nexus framework are usually too human-centric. In the Anthropocene, an objective function that only considers human needs up to decadal scales will not be sufficiently broad (e.g. McPhearson et al., 2021).

WEF has yet to be adopted as a framework for decision-making

While the UN and several other actors recognize the WEF nexus as a key concern (Cudennec et al. (2018); ICSU (2017); UN, 2021), the WEF nexus lacks the officially recognised status that has been achieved by, for example, the SDGs and Integrated Water Resources Management (IWRM) framework. The three sectors of the WEF are mentioned as a separate goal in the SDGs, each with their own sector-specific, and potentially conflicting targets. It is therefore clear that successful SDG implementation will require nexus thinking that considers the linkages and interactions between energy, food and water.

As such, this point implicitly raises the issue of how to solve conflicts between the different SDG targets. For us this also emphasises the importance of nexus thinking to complement sector-specific SDG targets. Based on our work, we see three challenges in SDG implementation being particularly important when considering WEF and water quality: 1) the diversity of local contexts, 2) overlapping scales of implementation, and 3) the problems of defining more comprehensive, cross-sectoral targets. Hence it may be an advantage to consider each of the goals separately and consider the relevant spatio-temporal scale of this goal. Doing this for the entire set of goals, including a similar mapping for the spatio-temporal scale of impacts from specific actions, will enable an overview of

the possibility for defining a suitable set of common spatio-temporal boundary conditions rather than assuming that a fixed concept is relevant for a broad spectrum of analyses. We see this approach being quite nicely aligned to the "hotspot thinking" discussed in Heal et al. (2021).

The WEF nexus thus seems to be most relevant in macro-level policy settings in which water, food and energy concerns (and not so much other sectors) need to be synchronized in terms of their primary resource usage. This is in line with the observations of Heal et al. (2021); their Figure 1 indicates that, although the WEF nexus has been adopted through a wide range of scales, a majority of cases appear in scales such as "city/aquifer/drainage basin," "region/nation" and "transboundary". The scale issue is also highly relevant when considering water quality, and hence we see the contribution by Heal et al. (2021) as an enabler with respect to ensuring a broader and comprehensive utilisation of WEF tools. Another possibility to enhance the uptake and relevance of the WEF nexus is to make use of indicator-based approaches with clear linkages between WEF nexus and the SDGs (Giupponi and Gain, 2017). Regardless, we must recognize that decision-making trends within WEF (or other frameworks) that are focused on solving specific issues may in fact neglect the overarching challenges (which require holistic, integrative approaches to ensure partial responses are avoided).

Focusing on windows of opportunity for sustainable change

The last point of discussion we wish to raise goes to the policy imperative for sustainable development and its linkages with WEF nexus and water quality. Building on the views provided by Heal et al. (2021), we want to expand upon why the uptake seems to be slow – both in terms of the WEF nexus approach in general, and the lack of awareness and/or action of water quality issues in particular. The concerns raised by Heal et al. (2021) should indeed make a strong case for action, and we agree that insufficient consideration of water quality is in itself a massive issue in the era of the Anthropocene. But how best to enhance the consideration of both water quality and the WEF nexus in the policy arenas, as well as in practice?

Our recommendation is to recognise and make better use of the relevant windows of opportunities to both raise the awareness on and push forward the topic of water quality and the WEF nexus in a consistent and forward-looking manner (see also Varis et al., 2014). Such windows of opportunities exist in relation to both general policy frameworks and different sector-specific policies related to e.g. energy, food and the environment – but they are often open for a limited time only, typically when specific policies or targets are set or revised.

We highlight two examples to further illustrate this point. At the global level, the increasing recognition of the complex linkages between the SDG targets is likely to enhance the recognition of nexus-thinking in the SDG implementation – including the consideration of water quality, given it is explicitly recognised as one of the targets under SDG6. This is important, given that the major challenge of the SDG framework is that its focus on separate sectoral targets may not address the variety of conflicts that exist between the targets. Water could be one of the crosscutters that help to both articulate and bridge the connections between the SDG targets, facilitating more systemic approaches (Taka et al. 2021).

At a more regional scale, in Europe, the EU's Water Framework Directive sets good water quality as one of the main aims for water management, with the European Green Deal and the recent agreement on a new Common Agricultural Policy emphasising cross-sectoral linkages and environmental aspects related to energy and food production. Finally, remembering the inherent

interconnection between human well-being and biodiversity, action plans as suggested by Tickner et al. (2020) must ensure that both aspects of the Water component are addressed simultaneously. This implies that both quantity and quality issues must be considered holistically – and ideally within such windows of opportunity when they arise – to ensure any trade-offs ultimately taken will not undermine the underlying goal of strengthening our adaptive capacity and resilience.

Conclusion

We see integrative thinking and sectoral coordination as fundamentally important when striving towards sustainable development through more comprehensive and inclusive policy-making and adjacent scientific and technical activities. The WEF nexus is an approach that attempts to tie three important sectors more closely together and identify win-win-win solutions among them. As such, Heal et al. (2021) address an important shortcoming in the contemporary way to adopt the WEF nexus, namely that water quality is far too rarely included in WEF studies. We thus see the intervention of Heal et al. (2021) as a highly relevant and important one and are principally in accord with their statements.

The breadth of recent papers on WEF clearly indicates that the discussion on how to frame the WEF nexus varies depending on the context in which it is considered. It may be seen as a sign that a clear framework will evolve, but could also be seen as an indicator that regional and local differences are too significant to be ignored. In the majority of these papers, inclusion of water quality in the evaluation of the WEF nexus is likely to improve the analysis. This will both emphasise that water quality considerations are a key aspect to include to ensure that the assumed synergies between the water, energy and food sectors can be met, but also that the linkages between water quality, biodiversity and pollution management must be typically considered simultaneously. This kind of integrative thinking is important, and it should include also the consideration of broader societal structures and power relations related to the use of natural resources (e.g. Allouche et al. 2015).

We have yet to identify the right balance between the positive aspects of solving domain-specific problems within the domain, and the negative aspects of ignoring the boundaries of the problem that only transdisciplinary approaches can solve. As such, we expect the discussions on the framing of the WEF nexus to continue for a while - just like the important discussion on whether to focus on human-centric or planetary boundaries for the transdisciplinary work that is needed to solve the problems of the Anthropocene.

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