frontiers | Frontiers in Water

ORIGINAL RESEARCH
published: 24 May 2022
doi: 10.3389/frwa.2022.787589

The Water-Energy-Food Nexus Beyond "Technical Quick Fix": The Case of Hydro-Development in the Blue Nile Basin, Ethiopia

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This paper builds upon empirical material from a case study of two dam sites in Ethiopia to revisit nexus narratives from a political ecology perspective. The two dams on tributaries of the Upper Blue Nile are examples of the success of hydro-development in increasing food and energy production, but at the same time they are evidence of the controversial effects these developments have on local populations. The paper argues that conventional nexus thinking has often been too water- and economy-centric, and too much focussed on a "technical quick fix" instead of a holistic approach. The paper calls for a broadening of nexus perspectives in order to better acknowledge the social complexity of hydro-development in local contexts, to understand the political construction of scarcity, and to combine different knowledges at the science-practice interface.

Keywords: nexus, hydro-development, Ethiopia, technical quick fix, political ecology, scarcity, science-practice-policy interface

OPEN ACCESS

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Specialty section:
This article was submitted to Water and Human Systems, a section of the journal Frontiers in Water

Received: *30 September 2021*
Accepted: *28 April 2022*
Published: *24 May 2022*

Citation:
Müller-Mahn D, Gebreyes M, Allouche J and Debarry A (2022) The Water-Energy-Food Nexus Beyond "Technical Quick Fix": The Case of Hydro-Development in the Blue Nile Basin, Ethiopia. Front. Water 4:787589. doi: 10.3389/frwa.2022.787589

INTRODUCTION

Since its first presentation at the World Economic Forum in 2008 and the Bonn conference in 2011, the conceptual framework of the water-energy-food (WEF) nexus has assumed the role of an agenda-setting new paradigm for water-related development in the Global South (Hoff, 2011; Smajgl et al., 2016; Simpson and Jewitt, 2019; Andrade Guerra et al., 2021). Nexus thinking aims at allocating scarce water resources more efficiently by integrating different scientific perspectives and harmonizing the needs of energy and food production (Allouche et al., 2014). Yet, the question arises whether the approach really lives up to its promises (Wichelns, 2017; Wiegleb and Bruns, 2018). To what extent does it provide a holistic understanding of the multiple relations between water, energy, and food? How can solutions based on the nexus embrace social complexity and water scarcity, and offer more than just a "technical quick fix"?

This paper builds upon empirical material from a case study in Ethiopia to revisit nexus narratives from a political ecology perspective. We believe that political ecology provides a suitable conceptual framework for the analysis of resource conflicts and development in the Global South, because it draws attention to the importance of agency, power dynamics, and socio-ecological relations as key issues of development (Johnston, 2003; Swyngedouw, 2009; Robbins, 2019). Ethiopia is a telling example of the relevance and challenges of the nexus approach, as the country is currently undertaking enormous efforts to utilize its water resources more intensively for national development and modernization (Müller-Mahn and Gebreyes, 2019; Gebreyes et al., 2020; Verhoeven, 2021). Our empirical observations in the Upper Blue Nile basin converge in two

main arguments. First, we suppose that hydro-development in Ethiopia shows little concern for the needs and interests of local populations at the dam sites, because it is driven by the government's ambitions for quick—and mostly technical—solutions to pressing economic and political issues. Secondly, we propose to broaden nexus studies by including political ecology perspectives, i.e., to make the approach more sensitive to complex social conditions and the consequences of state-driven development. In this article, we will first revisit the nexus framework and its conceptual challenges, then illustrate these challenges with our case study in Ethiopia, and finally discuss how to move nexus thinking beyond technocratic approaches.

CONCEPTUAL CHALLENGES OF NEXUS THINKING

Water is increasingly becoming a critical matter in global environmental change and development. Nexus thinking addresses the importance of the issue by focussing on water use for competing purposes, aiming simultaneously at an improvement of resource use efficiency, reliable energy production, and food security. The mainstreaming of the approach in development policy and practice responds to a 3-fold gap, consisting of a lack of finance, a lack of understanding of the feedbacks between resource systems, and a lack of communication at the science-practice interface (Allouche et al., 2019). The key idea of nexus thinking is thus to bridge these multiple gaps in order to manage scarce resources more efficiently, and to generate the necessary funds by mobilizing capital from domestic and international sources. Driven by international organizations like the World Bank and UN agencies, and supported by global economic players under the umbrella of the World Economic Forum, the proponents of the nexus approach envision a more active role of the private sector in order to broaden the financial basis of water-related development (Allouche et al., 2014).

While acknowledging the merits of the WEF-nexus as a managerial tool, a growing body of critical literature draws attention to conceptual weaknesses and blind spots in the approach. Some authors relate these deficiencies to the observation that nexus discourses have so far been dominated by natural science perspectives and neo-Malthusian thinking, which promotes quantitative assessments and technological solutions to social and ecological challenges (Wiegleb and Bruns, 2018). Critical voices are therefore calling for a pluralization of nexus perspectives, including a better recognition of power, hegemonial structures and justice (Allouche et al., 2019), sustainability pathways (Bhaduri et al., 2015) transboundary nexus governance (Dombrowsky and Hensengerth, 2018), and the practical application of nexus thinking in research and development (Leck et al., 2015).

Technocratic orientations tend to conceal the deeply political processes of decision making in the water, energy and food sectors (van Gevelt, 2020). As a consequence, the practical application of the nexus is often understood as a technical approach to managing trade-offs, without giving sufficient attention to the intricate relationship between causes, drivers and consequences. We agree with Allouche et al. (2019), who plead for a "knowledge nexus," i.e., integration of scientific knowledge and expertise from different disciplines. We also agree with van Gevelt (2020), who states that "wicked problems" such as the sustainable management of water resources for energy and food production require a better understanding of the political processes that shape policy decisions. Making the nexus more comprehensive and inclusive requires in-depth empirical research, as Wiegleb and Bruns (2018) point out, especially with regard to power relations and social inequalities. All these points converge in the call for "politicizing the nexus" (Williams et al., 2014).

This is where our study makes a contribution by questioning mainstream nexus approaches and their preference for technical solutions. We view this prevailing preference as a "quick fix," in the sense of solutions which seem to be fast and easy, but are in fact neither comprehensive nor sustainable (Schwanen, 2018; Williams et al., 2019). Technical or technological fixes rely on "the power of technology to solve problems that are non-technical in nature" (Markusson et al., 2017, p. 1). We take these critical propositions as starting points to address three questions regarding the nexus approach and its application in research and development policies.

How to Capture Complexity?

Nexus thinking claims to provide a holistic view of complex situations, but it has repeatedly been noted that its application is not holistic and interdisciplinary *enough*, or that it even deliberately excludes relevant information (Wichelns, 2017). The critique pertains especially to the social dimension, including intersectional relations, community structures, and local livelihoods (Givens et al., 2018). It also refers to the methods used in nexus studies, which are often confined to quantitative and economic aspects, without sufficiently recognizing qualitative social questions around nexus knowledges, informal practices and the complexity and boundaries of these systems (Allouche et al., 2019). We suppose that capturing complexity requires more nuanced approaches to understand microcontexts, such as in social constructivism, or feminist approaches (Haraway, 1988). This includes intra-household and gender relations, which so far have received little attention in nexus studies (Mdee, 2017; Villamor et al., 2020). Furthermore, understanding complexity needs to address cross-scalar relations, the risks and uncertainties emerging from hydro-development schemes, and the wider societal context regarding land ownership, livelihood changes, and environmental governance (Finger et al., 2006). All this feeds into the question of how nexus perspectives can be broadened to better capture the complex socio-economic and cultural conditions of water-related development.

How to Explain the Causes of Scarcity?

Narratives of "shortage" are key to nexus thinking, as the approach builds its legitimacy on the diagnosis of insufficient resource availability. The nexus approach seeks to mediate the effects of shortages by optimizing water use efficiency,

bringing its logics in line with neoclassical economics, and a strong belief in the power of markets. This aspect appears to be particularly relevant for Ethiopia, as the country has been repeatedly plagued by drought and famine, and the shortage of energy has long been a bottleneck for the government's growth and modernization policy. Conventional nexus studies have mostly addressed the uneven distribution of water availability from a water-centric perspective, taking scarcity as a natural fact. Yet, as we would argue, the issue is not just the quantitative availability of water, but its seasonal accessibility and entitlements for different user groups. We therefore propose to include the causes and dynamic changes of socially differentiated access to water. This is important in the context of hydro-development, as scarcity may also be socially produced due to the appropriation of water by dominant actors, or even as an unintended side-effect of development activities (Johnston, 2003). In view of these multiple causes, a political ecological approach helps to investigate water scarcity as the outcome of contested politics of allocation (Mehta, 2010).

How to Bridge the Science-Practice-Policy Divide?

The science-practice-policy divide concerns the lack of communication and knowledge exchange between different disciplinary silos, stakeholders, experts, and local populations (Allouche et al., 2019). Bridging this divide is difficult, because, as we assume, the reason for insufficient linkages between science and practice is not just a lack of knowledge, but the unwillingness to apply available knowledge. Policy makers do of course have to prioritize, but they tend to do so based on economics, while disregarding other aspects, and especially the human dimension. Furthermore, there seems to be an unresolved controversy between the analytical perspective of scientists researching nexus problems, and the perspective of development practitioners looking for practical solutions. The question arises how these multiple gaps between expert and lay knowledge, scientists and politicians, and planners and locals can be bridged.

Before presenting the case study findings, we need to briefly delineate what we intend to do in this paper, and what not. Our argument advances a critical position toward nexus thinking, which is, however, not meant to reject the approach, but rather to improve its analytical and practical capacities with regard to the three questions outlined above. Our position coincides with other social science studies and the works of the World Commission on Dams (Dombrowsky and Hensengerth, 2018). In line with these critical debates, we argue that nexus approaches should take the dynamics of uneven water development more seriously, especially with a focus on micro-level analysis. We will first outline our methodological approach and the general background of hydro-development in Ethiopia, then present the findings of our research at two dam sites in the Ethiopian Blue Nile area, and finally return to a discussion of the conceptual issues raised above.

METHODS

Our study builds upon a growing number of publications with suggestions how to make nexus research more inclusive by connecting local and expert knowledge (Cabello et al., 2021), quantitative modeling and qualitative futures thinking (Yung et al., 2019), or different social dimensions of the nexus (Biggs et al., 2015; Caputo et al., 2021). The empirical material used for this article comes from multi-sited qualitative field work at two medium-sized dam sites in north-western Ethiopia (Gebreyes et al., 2020). Both schemes are located on tributaries of the Blue Nile, but they are quite different in size, technical design and construction history (**Figure 1**). The Fincha-Amerti-Neshe scheme is a relatively large multi-purpose project built in three stages over a period of 30 years, while the Koga dam is a smaller, more recently established irrigation scheme to the south of Lake Tana. Fincha-Amerti-Neshe is located in Abay Chomen District of Oromia Regional State, a district with ∼65,000 inhabitants (CSA, 2013). The scheme serves electricity production, irrigated agriculture, a sugar plantation of around 25,000 ha and an adjacent factory. The main dam on Fincha River was built in 1973 under the Emperor, with a second one added on the Amerti river during the military regime in 1987, and a third one on Neshe river in 2011 (Müller-Mahn and Gebreyes, 2019). The Koga Irrigation and Watershed Management Project (hereafter Koga) is smaller and simpler in design and construction history. In contrast to Fincha and the GERD, its implementation did involve local participation (Eguavoen and Tesfai, 2012). Koga is located in the district of Mecha in Amhara Regional State, which is more densely inhabited with more than 350,000 inhabitants (CSA, 2013). The dam was completed in 2010, with a height of 20 m and a reservoir capacity of 83.1 million m^3 and a reservoir surface of 175 km^2. Its irrigated area amounts to 7,200 ha.

Our field research in 2019 and 2020 employed a mixed methods approach, combining focus group discussions (FGD) and key informant interviews (KII) with a total of 89 respondents, 17 of them women. Besides field work at the two dam sites, research also included expert interviews at different administrative levels, including the Ministry of Water, Energy and Irrigation in Addis Ababa, the Amhara Regional State water and agriculture bureaus, and two district offices of agriculture and water in Chomen District, Oromia Region, and Mecha District, Amhara Region. Field work was facilitated by research assistants in collaboration with local extension officers, and supervised by one of the authors. Field access was facilitated by the proximity of the study sites to the regional capital Bahir Dar, and more importantly, by close contacts to long-term key informants. In Fincha, research activities were temporarily hampered by tensions between the local farming population and the management of the Fincha sugar cane and irrigation scheme.

THE POLITICAL ECOLOGY OF ETHIOPIAN HYDRO-DEVELOPMENT

Political ecology offers a broad framework of approaches to investigate the structural causes of environmental crises at local,

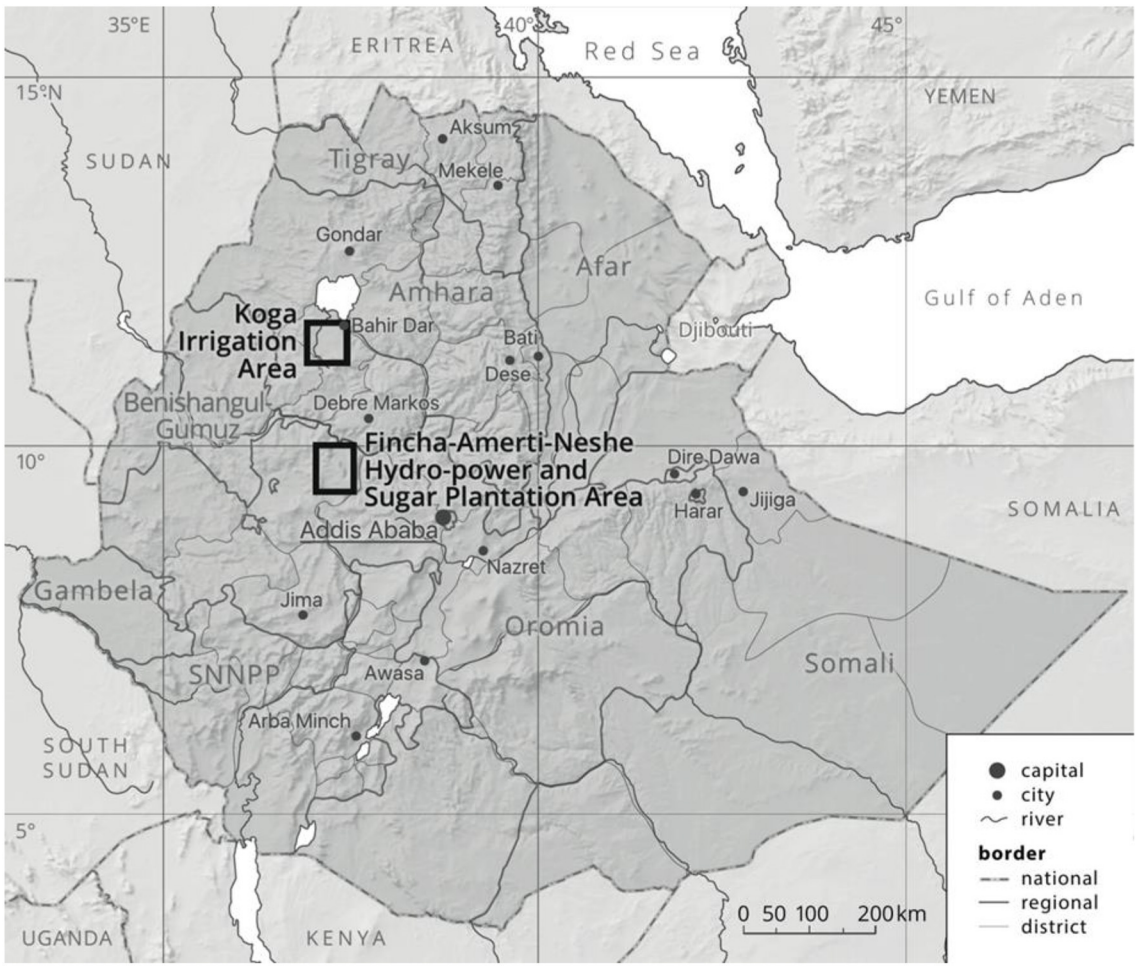

FIGURE 1 | Map of Ethiopia and the two case study areas.

regional and global levels in relation to the neoliberal world order and its power asymmetries (Perreault et al., 2015; Robbins, 2019). Case studies building upon this framework cover a wide range of topics, many of them in the context of the Global South (Bryant, 2015), and in combination with feminist (Rocheleau et al., 1996; Elmhirst, 2015) and post-colonial approaches (Breslow, 2014; Loftus, 2019). Hydro-development is one of the core themes, with a focus on urban water metabolism (Swyngedouw et al., 2002), hydro-social cycles (Swyngedouw, 2009; Linton and Budds, 2014), and neo-liberal patterns of water governance (Sultana and Loftus, 2019).

From a political ecology perspective, two characteristics of Ethiopia's recent hydro-development policy have been particularly influential. One is the specific architecture of power and its changes in the wake of radical regime shifts and international alignments in recent history. The second relates to the specific forms of environmental governance during different political regimes, which also include the geopolitical position of Ethiopia in relation to its neighbors in the Nile river basin. In the past, Ethiopia was repeatedly struck by severe droughts and famine, which left millions of people at the mercy of international relief organizations. With a population that rose from 22 million in 1960 to almost 120 million in 2020, consecutive governments gave high priority to projects that made use of the available water resources to produce more food, energy, and income for its citizens. This prioritization of hydro-development was further enhanced at the beginning of the new millennium, when high economic growth rates supported the push for modernization. Since then, national development has been driven by massive investments in the country's hydraulic resources, most visibly in the case of the Grand Ethiopian Renaissance Dam and numerous other large and medium-scale dams (Verhoeven, 2021).

Regarding these national plans, it is a truism that political rhetoric does not always coincide with reality. The history of hydro-development in Ethiopia reveals a striking contrast between the originally formulated targets and what has actually been achieved, such as in the last two 5-year strategic plans. The first Growth and Transformation Plan (GTP 2010-2015) aimed at bringing an additional 658,340 ha of land under irrigation, of which only 283,408 ha were realized, i.e., 43%

of the original target. In the same period, energy production was planned to increase from 2,000 to 8,000 MW, of which 4,180 MW was actually achieved, i.e., 52.2%. The second Growth and Transformation Plan (GTP 2015-2020) was even more ambitious, aiming at an increase of power generation capacity to 17,347 MW, an addition of 13,167 MW. The area of large and medium-scale irrigation schemes was planned to increase from 658,340 to 954,000 ha (National Planning Commission, 2016). Yet, the performance of the plan was even more disappointing than the first one, as the total increase of energy production amounted to only 299 MW, and the expansion of irrigated land remained far behind the target. Reliable official figures are not available, but there can be little doubt that this was not really a success story. Despite the poor performance in the past, however, the aspiration to use water as a driver of the country's development and modernization seems to be unchanged. The new 10-year plan (2021–2030) targets an increase of the current electric power generating capacity to 19,000 MW and an expansion of irrigation to 1.2 million ha (Planning Development Comission, 2020).

In the face of this discrepancy one wonders why decision makers continue a policy of hydro-development that has failed to achieve its goals so far, despite its perhaps over-ambitious promises? To answer this question, one has to take a closer look at the entanglement of national development, international relations, and power politics under the changing regimes in recent Ethiopian history. Since the rule of Emperor Haile Selassie (1930–1974), water resource development was strategically employed for the country's modernization and state-building (Lavers et al., 2021). It is remarkable to note that the focus on hydro-development persisted throughout all political regimes of the past half century, from imperial Ethiopia, through the socialist rule of the Derg, to current governments, but that all governments faced the same structural problem: finance. Dam construction requires massive financial and technical support from abroad, which makes the country highly dependent on foreign donors. Ethiopia is deeply entangled in the hydro-politics of the Nile, which was long subject to Egyptian hegemony (Waterbury, 1979; Hanna and Allouche, 2018).

Already under the Emperor's reign, plans for hydro-power development in Ethiopia were curtailed by US interventions in favor of Egyptian interests. As a consequence, Ethiopia was only allowed to develop a handful of hydro-power projects on the Nile, namely Fincha and Tis Abay, together with dams on the Awash river like the one at Koka. In addition to foreign influence, the Emperor's government also faced internal resistance from the nobility and some ethnic groups, to the effect that it was not able to pursue its plans for dam projects in the politically sensitive highland areas (Lavers et al., 2021). Later on, the military regime of the Derg (1974–1987) placed dams and modern state farms at the centre of its socialist vision of national development. However, the Derg's estranged relations with Western countries led to a lack of finance and technical support, and the cooperation with the regime's new ally the USSR only helped to build the hydro-power schemes of Melka Wakena and Gilgel Gibe I. During the time of the Derg, Western support by the European Economic Commission and the government of Italy was reduced to the construction of an additional dam at Amerti (an extension of Fincha Dam) and the Tana Beles integrated irrigation project.

The imperial government of Haile Selassie and the Derg regime failed to deliver their development vision as planned, which was to a large extent due to the fact that they were not able to provide sufficient energy. This may have contributed to the collapse of previous governments, as Lavers et al. (2021) argue, and presents a challenge for the current one. When the Ethiopian People's Revolutionary Democratic Front (EPRDF) came to power in 1991, it inherited only 370 MW of power generation capacity. Its 27-year rule saw an increase of this capacity to 4,180 MW, mostly from hydro-power sources. The improved performance under EPRDF rule may be explained by the party's use of the developmental state model in hydro-development (Lavers et al., 2021). The provision of cheap electricity facilitated industrial development, which in turn generated foreign exchange and served to legitimize the party's control of the state apparatus. With continued double-digit economic growth, expanded internal saving and diversifying foreign finance, the party was able to secure the finance needed to build mega-dams. With increasing geostrategic influence, it also managed to resist the harsh international pressure from Egypt against the largest dam under construction, the Grand Ethiopian Renaissance Dam (GERD). The decisions to prioritize hydropower development projects were largely made by top-level EPRDF leaders, with national technical experts playing only marginal roles. Successful electric power generation boosted the legitimacy and political control of the party, both nationally and regionally. Lavers et al. (2021) note that the developmental ambitions of the EPRDF political elites undermined expert-led planning processes in the water sector. As a consequence, local impacts of large dam projects remain highly contested. For example, Woldegebrael (2018) presents a detailed case study of the Gibe III hydro-electric development project, which describes how the power asymmetry between government decision makers and local communities leads to the marginalization of local communities and a deterioration of rural livelihoods. In a similar vein, Müller-Mahn and Gebreyes (2019) document the persistent livelihood threats for local communities in the Fincha-Amerti-Neshe scheme. The study of Mulugeta (2019) highlights contradictions between moments of inclusion and exclusion in irrigation management.

To conclude from the historical overview, the political ecology of hydro-development in Ethiopia indicates the pivotal role of water, energy and food for state formation and societal change. It explains the endeavors of consecutive governments for quick technical solutions, with little concern for their social consequences, as we will illustrate in the following case study.

CASE STUDY OF HYDRO-DEVELOPMENT IN THE BLUE NILE BASIN, ETHIOPIA

Capturing the Complex Dynamics of Hydro-Development

Putting national water resources to use for the country's development is a central pillar of contemporary Ethiopian

politics. However, this strategy inevitably invokes conflicts at the local, regional and international scales. Large infrastructures like dams and irrigation schemes inevitably interfere with local communities and may therefore have controversial consequences. Some people benefit from these interventions, while others are rather negatively affected. We refer to observations made at the Fincha and Koga dam sites.

The social and economic achievements of the described schemes are difficult to assess, as cost-benefit studies are not available, and the outcomes may be viewed differently at the national and local scales. At the national scale, one has to rely on project reports and policy papers indicating the ability of dam constructions to foster economic growth in the country through the generation of hydro-power, irrigation, fishery and tourism (Tefera and Sterk, 2008). Currently the combined Fincha-Amerti-Neshe dams have a power generating capacity of close to 230 MW. The irrigated land produces 270,000 tons of sugar and 8 million liters of ethanol per year (Gebreeyessus et al., 2021). The sugar factory consumes 21 MW of electric power per year and feeds an additional 10 MW into the national grid. A recent study of three large sugar plantations in Ethiopia views Fincha as second best in its water and energy use efficiency for the production of sugar, next to Wonji sugar factory (Hailemariam et al., 2019). With command areas of close to 7,000 ha, the Koga irrigation scheme with its focus on smallholder agriculture led to positive livelihood gains for its irrigation users in the form of increased household income (Kassie and Alemu, 2021).

Despite these positive contributions to the larger economy, however, the combined hydro-power and sugar plantation infrastructures are also considered as drivers of deterioration in the wetland and forest ecosystems in the area (Tolessa et al., 2021). The Koga irrigation scheme is criticized for failing to translate household income gains into an improvement of food security for beneficiary households (Kassie and Alemu, 2021). Furthermore, limited participation in key decisions, irregularities in handling compensations, and broken promises of compensation for those displaced by the dams contributed to disproportionate social costs for people living in the dam areas (Tefera and Sterk, 2008; Eguavoen and Tesfai, 2012).

"Water" may have many meanings, especially in the context of development. Conventional nexus approaches conceive water as an economic resource, which is measured in terms of efficiency and productivity. For local populations, however, water is primarily a source of life and the very basis of their livelihoods. The economy-centered view of the nexus often neglects the social and cultural aspects of water, especially when it comes to adverse side effects resulting from an economization of water (Finger et al., 2006). This concerns, for example, water access at the level of communities, the division of labor within households, or health issues (Swyngedouw, 2009). Many respondents in our case study said that water-related developments had seriously harmed their traditional drinking water supply from small rivers and freshwater springs. In the words of a male informant:

> "Before the dam, there were six clean springs for drinking. There was also the river to use for irrigation. The dam impounded all of this and now we are left with nothing. The project has done nothing to support the community in setting up water facilities." (KII near Neshe I)

The demolition of traditional water access points is particularly detrimental to women and girls who are commonly responsible for fetching water. They often complain that the dam and irrigation schemes has made fetching water more laborious.

> "The dam consumed many of our springs and rivers. People suffer from lack of clean water. Some have to walk long distances to get drinking water, some even dig for ground water. Our livestock drink from the dam water, but this causes health problems." (FGD near Fincha)

In some areas, the government provided shallow wells equipped with hand pumps and taps. A nominal fee is charged, which the rural poor are often unable or unwilling to pay, as two female respondents at the Koga dam site explain:

> "Before the dam, we used spring water which we women keep clean. But currently we use tap water. However, those who cannot pay for the tap water are suffering."
> "The government provided tap water. But to get it, you have to pay [. . .]. Poor people who cannot pay are forced to drink water from the dam."

These development-induced hardships for rural women concern not only the water supply, but also energy, as another quote from a focus group discussion with women in the Fincha area indicates. Women have to walk long distances to collect wood or to transport grain to the mill.

> "We use wood for cooking and kerosene for lighting. We have to walk 3 h on foot to the mill at Finchawa town."

The quotes indicate that gender and intersectional aspects play an important role in the changes caused by the new dams. The achievements and burden of modern developments are unevenly distributed, often to the disadvantage of women. Female-headed households are particularly badly off, because they often cannot provide the increased labor input and capital required for irrigated agriculture and therefore tend to rent out their land to better-off farmers.

Furthermore, the new infrastructures and large reservoirs disrupt spatial connections, inundate places of worship, and destroy neighborhoods, with detrimental effects on social cohesion, as the following two interview statements indicate.

> "In the past, people maintained strong ties among each other. We used to eat together during good times and also get together during bad times. After the dam, however, it became very difficult to cross the lake, and people could not see each other so easily. They even do not go to the market as often, because boat transport is difficult." (KII near Amerty II)
> "Before the dam, people residing in different kebeles had close relationships. We helped each other during bad times. We had horses and mules for transportation to move from one place to the other for social gatherings. After the dam, all these ties are declining because the dam disconnects us." (KII near Amerti 4)

The social context mentioned in the interviews above also concerns the food and energy dimensions of the nexus. During our field work, we came across many cases where the reservoirs flooded farm and grazing land, and thereby disrupted food and fuelwood production. The benefits and burdens of the new schemes are unevenly distributed. While some people were lucky and gained better access to water for irrigation, extension services, and markets, others were cut off from these opportunities or even evicted from their farmsteads and land. Community members at the Fincha scheme were particularly outspoken on this issue, complaining that they had lost land due to the construction of the dam and the sugar plantation, without receiving anything of what was produced by the scheme. In addition, the reduction of communal grazing land became a serious problem for many livestock holders.

> "We still live in the dark, with no access to electricity despite producing electricity for the nation for already 50 years. We buy imported sugar at high price, but have never seen the sugar from Fincha factory in the local market." (FGD near Fincha)
> "Before the dam, we had enough grazing land and the cows were productive, so that we often ate milk products. But now, we do not have sufficient pasture, the consumption of milk products gets less. How can I provide milk when I am stopped at the gate?" (Female household head at the dam site)

Dam and irrigation schemes generally go along with a reduction of pastureland, which had previously been a key livelihood asset and a means of combined agricultural and livestock production. Loss of land without compensation creates a high risk, especially for female-headed households, as they often face severe cultural constraints in agriculture and are therefore more vulnerable (Alesina et al., 2013; Alebachew, 2018). Prevailing restrictions that prevent women from plowing and farming their land on their own force many of them to lease their land, as the following statement indicates:

> "Female-headed households face many constraints to farm their land, like the shortage and high cost of inputs and the shortage of male labor force. If you do not have a son to till the land, culturally it is a shame for women." (female participant in a focus group discussion in Abiot Fana village at the Koga dam site)

Our case study also revealed that the benefits of development in terms of education, health, safety, well-being, and the provision of electricity were not available to all members of local society (Bos et al., 2018).

> "We use traditional boats, but many people did already drown. Now it is difficult to go to the market, health centre, and court. We cannot send our children to school. Nobody is willing to see our problem." (KII near Amerti 4)

Another point concerns the meaning of energy in the context of nexus studies. From a local perspective, energy is more than just electricity, but also includes fuel for cooking, charcoal, and fodder for oxen used in plowing. In the case of Koga, we observed a massive expansion of eucalyptus plantations in recent years. This practice is officially forbidden, but farmers grow more and more trees as a response to the high demand for fuel and timber. Cultivating eucalyptus trees places farmers in conflict with the original goals of irrigation schemes. When the Koga dam was constructed, farmers were ordered to remove the trees and to stop growing eucalyptus on the irrigated land. However, eucalyptus production is thriving in the surrounding non-irrigated areas, because it is highly profitable, requires little labor, and can be handled with low risk.

> "Irrigated agriculture is demanding, with long hours of work throughout a production season, two to three times a year. Even after hard work, the benefit depends on getting a good market price. Eucalyptus does not need hard work. Marketing is also not an issue. Often the traders go from farm to farm to buy from the farmers. As a result, farmers prefer eucalyptus over irrigation." (FGD with Mecha District Agricultural Office Experts)

Irrigated agriculture is generally a risky business, due to marketing problems, price volatilities, and insufficiently organized services, as the following statements indicate:

> "Farmers produce either too much or too little of a certain product at a time. This year they produced a lot of onions and cabbage and could not sell everything. Farmers fail to produce the amount that is suitable for the market demand." (FGD with district experts)
> "Members of our cooperative complain that the officials are good at getting seeds to the farm but incapable of creating market linkages for the products." (FGD with Adbera Block Coop Leaders)

These data show that technical, economic, and social challenges remain even under irrigation, once again underscoring the importance of taking local conditions into account in nexus studies.

The Political and Social Construction of Scarcity

The previous section has described the multiple disruptions of local livelihoods at the Fincha and Koga schemes, including access to water, land rights, labor relations, livelihood risks, and intra-household responsibilities. Altogether, these side effects of dam construction have led to the emergence of new forms of scarcity at the level of local communities. When the first Fincha dam was constructed during the reign of emperor Haile Selassie, land was considered as the property of the crown and administered by local notables who could dispossess landholders without compensation (Cohen, 1973, p. 367–68). State-led modernization and electrification did not aim at improving the living conditions of rural populations, but served the interests of urban centres and the elite (Clapham, 2006). Therefore, the hopes of rural populations were high when the monarchy was overthrown by the socialist military regime, and the Derg abolished the landlord-tenant relationship in its famous 'land for the tiller' proclamation (Rahmato, 1993). However, the socialist regime embarked on state-controlled rural transformation, which renewed the dispossession of the peasants by setting up huge state farms and sugar factories (Clapham,

2006). A respondent in Abay Chomen District, Oromia Region, described the history of Fincha as follows:

> "In 1974 the Derg came to power and declared that the land belonged to the tiller. Everyone was happy and thought that the lost land will be returned. The unfortunate story is that people were told that the land is needed for sugar plantation and they were made to lose additional plots of land. They lost their fertile land once and for all. The people kept on complaining, but there was no venue for their voice to be heard."

When the Neshe extension was added to the Fincha scheme in 2011, Ethiopia was just moving from a phase of centralized top-down development to more liberal approaches of pro-poor development and the recognition of people's rights (Gebresenbet, 2015). Hence, the Neshe project provided a better deal for local farmers compared to the two previous dams in the area. The government offered either financial compensation for the loss of houses and farm land, or a new house and land at another place. Many people accepted the second option, together with a share-cropping arrangement with the sugar-cane plantation and an additional piece of irrigated land. In practice, however, the promises were not fulfilled. The shabby houses built as compensation did not last long, the share-cropping arrangements did not work out as planned, and farmers had to wait for years until they got paid for what they had delivered to the sugar company. As a consequence, many people faced a catastrophic deterioration of livelihoods, as the following statement by a respondent at the Neshe dam area indicates:

> "I thank God that you come to ask us about these problems. I have 12 children. I owned 5 ha of land which they took from me. I had three houses which are all gone now. And they never compensated me for the houses or the land. I am separated from my children, they are everywhere, wandering here and there. Now I am very poor and my life is very hard. I don't even know where my children are."
> (Focus Group Discussion Respondent, Homi Village, Abay Chomen District, Oromia Region)

The situation at the Koga irrigation scheme is different from that at Fincha in so far as more attention was paid to local participation and the needs of smallholders, at least in the original implementation plan. The Koga scheme is politically embedded in the development ideology of the Ethiopian People's Revolutionary Democratic Front (EPRDF), which aimed at creating a social consensus among citizens in its attempts to escape poverty and modernize society (de Waal, 2013). However, the declared goals of social equality and participation were only half-heartedly translated into practice. Similar to the older dams, farm land and pastures were confiscated and only partially compensated, with the effect of a rising gap between better-off and poor farmers. This is illustrated by the following interview excerpts:

> "They took away my land of 0.75 ha. Some people got replacement, some not. It was just luck, some got new land, some did not. I am now left with only my house. I am a laborer. I cut eucalyptus trees for other farmers. That is how I support my family. I once owned two oxen, before the dam. I sold them when the dam took away our grazing land to buy grain for my family. Life was better before the dam. I owned livestock and land to farm, I could provide a decent life for my family. Now I support my family through manual labor. Mostly, I work here in my village. But in the peak season, I migrate to far-off places to work. I travel to Tigray and Benshangulgumz regions to work for rich farmers."
> (Interview with poor farmer, Abiot Fana village).
> "I lost (some of) my land because of the dam. That is the only down side. Otherwise, all the surplus production is benefiting our village, our market is full of vegetables. All neighboring towns and even Bahir Dar depend now on irrigated agriculture. So even if I am not directly benefiting from the irrigation scheme, I see its benefits. I see that the irrigation scheme is very important for the economy in the surrounding areas in general."
> (Interview with rich farmer, Abiot Fana village)

The above examples give testimony to the fact that the benefits of hydro-development are unevenly distributed, while parts of the rural population are deprived of access to land and water altogether. As a consequence, resource scarcity may be considered as a socially produced problem, and a side-effect of modernization and hydro-development.

The Science-Practice Divide

The prominence of the nexus concept in scientific debates is in stark contrast to its rather marginal role in day-to-day development work in Ethiopia. Nexus debates are by now well established in the community of international donor and research organizations, in particular among members of UN and CGIAR institutions (see, for example, Stein et al., 2014a), and scientists working at institutes for development studies (von Braun and Mirzabaev, 2016; Allouche et al., 2019). Nexus thinking was promoted by donor-funded research[1], and by the mainstreaming of the approach in long-term strategic plans[2] On the other h and, relatively little of this seems to have arrived in development practice on the ground, at least in the case of Ethiopia. However, the fact that many Ethiopian government officials are not yet familiar with the term and its contents is not surprising, given the relative recency of the nexus concept. In our interviews with senior experts at various government institutions, including the Federal Ministry of Water, only one had heard about the nexus at a conference. This observation may be explained by viewing the nexus as a "traveling model", i.e., as a model or concept that originated as a Western idea and is being transferred to development contexts in the Global South (Wiegleb and Bruns, 2018). In the case of Ethiopia, it seems that the traveling model has not yet arrived in the offices and minds of decision makers.

Furthermore, the fact that Ethiopian government officials and planners are not yet familiar with the nexus terminology does not mean that the idea behind it is new to them. On the contrary, most of our respondents at all levels, from

[1]https://wle.cgiar.org/project/water-energy-food-nexus-global-basin-and-local-case-studies-resource-use-efficiency-under

[2]https://sustainabledevelopment.un.org/content/unosd/documents/4536Water-Energy%20Nexus-Ethiopia-Final.pdf

ministries to village administrations, were well aware of trade-offs between water, energy and food, without knowing of any conceptual underpinnings. The importance of systemic water-related connectivities is self-evident for everyone who is professionally engaged, as one of our informants from the Ministry of Water put it:

> "We may not use the term nexus, but the interconnection of water, energy and food is obvious in our ministry's mission and actions." (KII, senior expert, Ministry of Water).

The rationality of development practitioners centres on economic problems, political guidelines, and technical solutions:

> "The policy is clear. Our policy direction is to build multi-purpose dams. That is what you see in most of the projects identified in the basin master plan." (KII, senior expert, Ministry of Water).

The understanding of water-related development as an engineering operation is also reflected in Ethiopian policy documents and national plans. The Poverty Reduction Strategic Paper (PRSP) of 2002, for example, states that "Ethiopia cannot hope to meet its large food deficits through rain-fed production alone," and it therefore calls for the construction of big dams and irrigation schemes. The two recent 5-year plans put hydro-development at centre stage, portraying dams as the key to modernization and future prosperity.

Bridging the science-practice divide is a matter of communication, knowledge, and learning in order to make nexus approaches more inclusive (van Gevelt, 2020). In a similar vein, Allouche et al. (2019) call for a "knowledge nexus" that integrates different nexus narratives. Stein et al. (2014b) use a participatory network mapping of relevant actors and their institutional interplay in the Ethiopian Blue Nile basin, showing that "collaborative learning processes can play an important role in moving toward better coordination between key actors and improved development planning" (Stein et al., 2014b, p. VII). However, overcoming the science-practice gap in nexus debates is a matter not only of different degrees of knowledge, but also of priorities. The policy makers and development practitioners we talked to showed little interest in the societal consequences of dam construction. This is obviously not a question of knowledge and understanding, but rather a response to political directives, which currently leave little space for alternative approaches and bottom-up perspectives.

DISCUSSION: BROADENING NEXUS PERSPECTIVES

This article employs a political ecology perspective to scrutinize the capacities and limitations of the nexus approach in understanding water-related development. The main argument is summarized in **Figure 2**.

The case study highlights the controversial effects of hydro-development in Ethiopia, which has contributed to implementing the national development agenda through the enhancement of energy and food production, but with detrimental effects for local communities and people living at the dam sites. In the face of these contradictory development outcomes at the national and local scales, we argue for an acknowledgment of power dynamics and social conditions in nexus perspectives and their practical application. The study points to the uneven distribution of water rights, the role of political institutions, and the importance of power hierarchies, in order to better understand complex local conditions and the causes of water scarcity. It questions the prevailing water-centric focus of conventional nexus thinking, showing that water may be both a tool for development, and a cause of dispossession and scarcity. We have structured the empirical observations of the case study in terms of three questions relating to complexity, scarcity, and the science-practice divide, which we will now relate to the conceptual reflections presented at the beginning of this article.

Concerning the first question, we agree with (Bakker, 2010) and Allouche et al. (2019) that nexus approaches have emphasized economic trade-offs and synergies, but failed to sufficiently acknowledge the social dimension of water-related development. Arguing from a political ecology perspective, we view the belief that new technologies and the free play of market forces are able to solve global challenges as a brainchild of neoliberal logics. We find the prevailing confidence in technological progress problematic as long as it remains blind to the complexity of socio-ecological crises. Our skepticism is expressed in the term "technological quick fix" in the title of this paper. It means that solutions based on the idea of a technological fix are, in the words of Rosner (2004, p. 3) "partial, ineffective, unsuccessful, threatening, one-sided as opposed to holistic, mechanical as opposed to ecological."

An important finding of the case study is the observation that the achievements and burdens of modern development are unevenly distributed between urban and rural populations, between the different people living at the dam sites, and between members of the same community or household. The issue has been repeatedly raised by feminist studies, which have long pointed out that natural resources are intertwined with subjectivity, power, and spatiality (Sultana, 2007, 2009; Thompson, 2016; Harris et al., 2017). Nexus approaches must take these aspects into account to avoid seeing women (and water users in general) only as rational users whose daily experience with water can simply be remedied by technical solutions. This also applies to the impact of dams and irrigation schemes on labor relations within households, because these developments often go along with higher workloads for women. In response to these issues, we propose to broaden nexus perspectives by recognizing gender and intersectional relations, the impact of new projects and technologies on women and female-headed households, and the consequences of dam construction on displacement, social disruption, and transformation of communities.

Regarding the second question, our empirical findings support the political ecology argument which understands water scarcity as a social construction, and as the outcome of historical processes. From this perspective, the production of scarcity is related to property rights, dynamic changes in water use systems, and the political framework in which these changes unfold (Swyngedouw, 2004; Mehta, 2010). As Swyngedouw (2004, p. 47) points out, "the discursive production of water 'scarcity' is invoked in order to serve specific political goals." This applies to

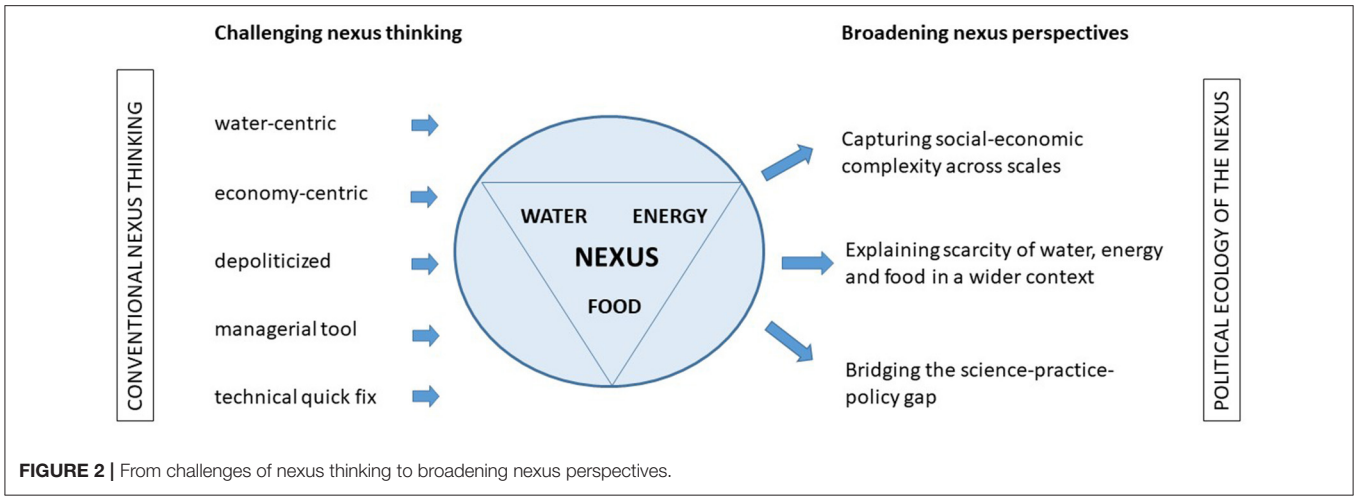

FIGURE 2 | From challenges of nexus thinking to broadening nexus perspectives.

Ethiopia, where consecutive governments have presented hydro-power dams and irrigation schemes as prerequisites of national energy and food security policies, and therefore as corner stones of modernization. Since the 1990s the country has pursued a strategy of industrialization to diversify the economy, which largely depends on hydro-power production and the expansion of irrigated agriculture. Against this backdrop, the spectacular mega-dam projects GERD and Gibe III not only serve to implement the national development agenda and the ambitious Growth and Transformation Plan of 2010, but they also play a highly symbolic role in state-building amidst growing tensions between the regional states, and attempts to maintain the central power of the developmental state (Woldegebrael, 2018).

The study also reveals that hydro-development is not only a response to perceived or discursively constructed scarcities, but may itself become a driver of newly emerging scarcities. Our observations provide evidence of the simultaneous production of scarcity and abundance. While some members of the local communities in the Koga dam area have benefited from improved access to irrigation water, others have been deprived of land and water, in some cases without compensation. In the light of these very diverse impacts of the hydro-development schemes we have investigated, we argue that scarcity concerns not only water, as conventional nexus thinking implies, but also land, employment, or, more generally, human security and equitable development. Conventional nexus perspectives view scarcity mostly in terms of quantitative resource availability. Based on this case study, we argue that the quantification of indicators should be complemented by an understanding of the qualitative aspects that also play a role in shaping the nexus.

The third question relates to the science-practice divide and how it may be overcome. This is where we see the main challenges for improving nexus approaches, because the divide is deeply entrenched in politics. The narratives revolving around scarcity, water use efficiency, and technological solutions tend to conceal the political processes of decision making in the water, energy and food sectors (van Gevelt, 2020). As a consequence, the practical application of the nexus is often understood as a technical way of managing trade-offs, without giving sufficient attention to the intricate relationship between causes, drivers and consequences of scarcity and the uneven distribution of water. Broadening nexus perspectives means incorporating research on subjectivities, gendered power relations and inequalities at both the national and local scales. It requires a "knowledge nexus" (Allouche et al., 2019), i.e., integration of scientific knowledge from different disciplines, together with vernacular knowledges. Recent studies have shown how local and expert knowledge can be connected to make nexus perspectives more holistic (Yung et al., 2019; Cabello et al., 2021). Bridging the science-practice-policy divide therefore requires not only "joined up thinking" (Allouche et al., 2019), but also the integration of different forms of knowledge, including local and indigenous knowledge.

CONCLUSION: ADVANCING THE NEXUS BEYOND A TECHNICAL QUICK FIX

We began this article by highlighting the importance of nexus thinking and its endeavors for a holistic understanding of the interconnectedness of water, energy and food. While acknowledging the merits of the approach, we also raised the question whether it is holistic enough to capture the social and political complexity of the micro-geographies of water-related development. The reason why we find this important is exemplified by the case study, which shows that the Ethiopian government's hydro-development policy has been successful in increasing national energy and food production, but at the price of highly problematic consequences at the local level. In view of these controversial outcomes, we propose to broaden nexus perspectives beyond a water-centric focus by better acknowledging the social and political aspects of hydro-development. We have used a political ecology perspective to highlight the uneven distribution of water rights, the role of political institutions, and the importance of power hierarchies. These findings go beyond the scope of conventional nexus approaches, because they show that water may be both a tool for development, and a cause of dispossession and scarcity.

Advancing nexus perspectives beyond a simplified water-centric focus has an analytical and a practical dimension. Concerning the analytical dimension, our case study in Ethiopia shows the drawbacks of the investigated hydro-development schemes at the local scale, which are often overseen when only the benefits of dams for national development are considered. We attribute this biased view to the fact that top-down projects tend to centre too narrowly on economic interests and technical solutions. Our expert interviews and focus group discussions document a striking contrast between the development visions of government officials and the critical statements of local respondents. Many locals feel disadvantaged by the state-driven modernization policy, because they are excluded from the benefits of the new schemes, or because the achievements did not meet their expectations. Regardless of whether these critical statements tell the truth, one can interpret them as expressions of disappointment. It is important to note that local voices have remained largely unheard in the course of top-down project implementation under various political regimes in the country's recent history, causing discontent and friction between rural populations and the government.

Our call for a broadening of nexus perspectives also has methodological implications. It requires an interdisciplinary approach, which acknowledges the social dimension, as well as the historical and cultural context of water-related development. We therefore support a stronger focus on qualitative ethnographic methods to understand local voices, grassroots movements, intersectionality, indigenous knowledge, and the social dynamics of local communities. Mixed-methods approaches may help to overcome the limitations of disciplinary silos and modeling-based quantitative approaches, and capture the articulations within and between different drivers of resource use systems.

The practical dimension of broader nexus perspectives concerns the question how to translate the analytical approach into feasible action plans. On the one hand, we argue that understanding the complexity of socio-cultural conditions and the socially differentiated causes of water scarcity is vital for identifying strategies of water allocation, but that this knowledge is rarely present in development planning. On the other hand, we must concede that a high degree of knowledge does not necessarily lead to better planning. Obviously, this requires bringing complexity back to manageable solutions.

The Ethiopian case provides evidence of the importance of nexus thinking in a truly comprehensive way. To this end, the nexus should be moved beyond a technocratic approach or a technical quick fix. It should broaden its perspectives to include not only the systemic connections between water, energy and food, but also the social consequences of water-related development. With the current return of big dams and hydro-power infrastructures, and renewed interest in water through the water-energy-food nexus concept, the apolitical nature of such fashionable global policy framings should be critically assessed. The call to "socialize" and "politicize" the nexus is therefore perhaps the most important conclusion to be drawn from our empirical study. We suppose that in the long run hydro-development cannot be imposed on local populations against their needs and interests, at least not without considerable collateral damage.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

DM-M took the lead and was responsible for the conceptual argument, together with JA. MG did the empirical field work, supported by AD. All authors have contributed to writing the article.

FUNDING

The funding for this paper came from the German Research Foundation, through the Belmont Forum funding scheme.

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