frontiers | Frontiers in Sustainable Food Systems

SYSTEMATIC REVIEW
published: 05 April 2022
doi: 10.3389/fsufs.2022.734675

Analysis of the Complexities in the Water-Energy-Food Nexus: Ghana's Bui Dam Experience

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The quest to improve the mired development challenges of developing economies at a global scale have in recent years constituted policy imprimatur of development discourse, including the role of national and local resources. "Nexus" is an ultra-prioritized integrative global development approach. It denotes connection(s) linking two or more phenomena or variables. It is therefore not surprising to witness of-the-moment approaches such as the development-security nexus, migration-development-security nexus, and water-energy nexus, among others. Particularly relevant to this article is the water-energy-food (WEF) nexus as an integrative strategy to tackle prosaic issues of industrialization, poverty reduction, food security, and ecological sustainability. Adopting a qualitative methodological approach, the article studies the Bui dam to elucidate how the nexus operates in a complex and tense environment. The central argument is that most analyses of WEF interventions, particularly from the mainstream development literature rarely interrogate complex politics of interest amongst the trident sectors (water, energy, and food). The dominant studies tend to dwell on the technical or instrumental aspects. But an understanding of the complex relationships at play needs a critical approach. Our key argument is that the WEF nexus is prominently embedded in complex historical systems that tend to counter-balance the hyper-deductive projected costs and benefits. It is critical to view the relations amongst the WEF from a non-linear and realistic perspective. WEF as an embodiment of a complex system helps us to understand the multi-level, contradictory, and diverse interests at play within, between, and across the systems. Even though the nexus operations on an assumption of seamless collaborative relations among and between institutions, agencies, and actors in the policy and program implementation space, an analysis of the Bui project in Ghana shows tensions, side-lining, and inter-role conflicts among the actors, where the energy sector actors weigh power and resources over other institutions and actors in the space to drive the nexus.

Keywords: water-energy-food (WEF) nexus, sustainability, relational, non-linear, Ghana

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Water-Smart Food Production, a section of the journal Frontiers in Sustainable Food Systems

Received: *01 July 2021*
Accepted: *02 March 2022*
Published: *05 April 2022*

Citation:
Siakwah P and Torto O (2022) Analysis of the Complexities in the Water-Energy-Food Nexus: Ghana's Bui Dam Experience. Front. Sustain. Food Syst. 6:734675. doi: 10.3389/fsufs.2022.734675

INTRODUCTION

Resources, including water, energy, and food are important for the social and economic (re)production of societies. There are, however, complex relationships among these resources in terms of their sustainable use. It is within this framework that the question of the water-energy-food (WEF) nexus arises. Globally, dams are avenues to analyze the interface between water, energy,

and food politics. A dam can be constructed for hydropower (energy) and the water stored in the dam become a source for agriculture activities—irrigation and fishing. But the quest to optimize human needs on one hand and the securing of the environment and natural resources to promote sustainable development on the other has led to the framing and prioritization of the WEF nexus. Richter et al. (2010) observed that the construction of large dams in the global south has threatened the lives and livelihoods of at least 470 million people. This adverse consequence of dams is the outcome and manifestation of a defective social system that produces such disequilibria. It is within this frame that efforts are being made to coordinate the various resources and systems to ensure sustainability. The "nexus" notion has gained a degree of orthodox acceptance as means to solve complex human problems at multi-scalar levels (Gillson and Marchant, 2014). Thus, one can notice the adoption of the aid industry interventionist approaches such as the development-security nexus, development-migration-security nexus, and population-environment-poverty nexus. It is also worth noting that a vital confluence of forces/factors has coalesced to create demand for diverse integrated management approaches, an imperative need. Leck et al. (2015) and Hoff (2011) for instance, identify forces such as globalization, urbanization, population growth, and changing lifestyles as posing precipitous demand on the natural ecosystem. Yet, we must take cognizance of the varying regional differences in resource pressure within the global system. It is essential to note that the relationship between resources and human development is not unidirectional.

The World Economic Forum in Davos in 2011 brought the Water-Energy-Food nexus (WEF) to global policy attention and investment priority. Ever since, there have been several fora of international institutions, academia, governments, and civil societies, coalitions, and research reports to consolidate interest in the WEF. There are significant studies on the technical assessments of the WEF, life cycle analysis, trade-offs, and risk assessments. Furthermore, the quest to meet the SDGs on industrialization, economic growth, and poverty reduction has equally shaped institutional interests and ideas toward an integrated management or joined-up approach.

In Africa, hydro dams are important in meeting the complex societal needs of energy and of water for irrigation and food production. Countries have built energy resources, including dams to drive their socio-economic development. Since the 1960s, Ghana has made efforts to increase and diversify its energy into hydro, thermal, and other renewables (Obour et al., 2016). The hydro sources include Akosombo, Kpong, and Bui. Bui dam, the focus of our study, is the second-largest hydroelectric plant after Akosombo. It is constructed at the Bui Gorge on the Black Volta (Darko et al., 2019). The construction of the Bui between 2008 and 2013 belongs to the second phase of large dam construction in Africa, making it an excellent case study for understanding the contested nature of these dams (Gocking, 2020). The construction of Bui multi-purpose dam is framed within the WEF nexus, providing energy and water for farming.

In this paper, we observe that the articulation of the WEF nexus in a normative sense denotes the presence of effective collaborative relations amongst the key actors to ensure the success of the mutual objectives. However, in Ghana's context, we argue that the presence of such collaborative/integrative relations amongst the disparate institutions, agencies, and actors is rare. Rather, what is manifestly evident in the case of the Bui is the imbalance in power relations that imbues it as the lead agency with enormous power, which ruins the coordination, comprehensiveness, and coherence required of a nexus project. Thus, the general objective of this paper is to explore the contradictions and incoherence nexus outcomes of the Bui project. This paper proceeds as follows: first, the theoretical perspectives of complexity, followed by the empirical manifestations of complexity-driven megaprojects. The third section focuses on the background to Bui Dam and methodology and is followed by the Bui Dam energy in Ghana development context. The fifth section is on the irrigation development prospect of Bui: conceptualization and implementation deficiencies and ends with a conclusion section.

THEORETICAL PERSPECTIVES OF COMPLEXITY

Given our preference for complexity (complex systems), it is crucial to distinguish them from simple systems. We adopt Rosen's (1987) distinction between the two systems:

> "a simple system is one to which a notion of state can be assigned once and for all, or more generally, in which Aristotelian categories can be independently segregated from one another. Any system for which such a description cannot be provided I will call complex. Thus, in a complex system, causal categories cannot be intertwined in such a way that no dualistic language of state plus dynamic laws can completely describe it" (pp. 324).

Complexity according to Stewart (2001) refers to a matter of perspective or framing (which in our case relates to human intentions and interests, and the wider ecology), depth of detail, and the outcome of knowing through multiple lenses. The quest to understand a particular phenomenon would require closing in on local knowledge as well as a broader knowledge of structural, systemic, and environmental histories. In the light of the essential emergent nature of complexity, it can also be defined as "Within science... complexity is the study of the behavior of macroscopic collections of (basic but interacting units) that are endowed with the potential to evolve."

According to Luhmann (1985), apart from the differentiation and unpredictability features of complexity, indeed, complexity is utilized in an existential way. He posits that complexity is a problem, and people need to be "shielded from the immense complexity and contingency of all the things which could be deemed possible" (1985, 16). Luhmann distinguished this immense complexity of the world from a lesser but increasingly problematic complexity produced by social systems and their interrelations; it is this latter complexity that Luhmann wrote about, with a pronounced organismic characterization of this social system. Particularly, the WEF individually embodies different multi-scalar social systems, in which some might have

exhibited contradictory and contestable relations. For instance, as suggested by Richter et al. (2010) the construction of large dams in the global South has threatened the lives and livelihoods of at least 470 million people, mainly in the global South. This adverse consequence of large dams is steeply an outcome of a defective social system that produced these avoidable disequilibria.

Irreducibility of complex systems is more of the norm than an exception. Cilliers (1998) explains that a 'complex system cannot be reduced to a collection of its basic constituents, not because the system is not constituted by them, but because too much of the relational information gets lost in the process. Bonta and Protevi (2004, p. 23–24) following the philosophical perspectives of Guattari and Deleuze that this irreducibility of any complex system makes it impossible to predict their working exactly. They expand on this as follows:

> Two reasons—one practical and the other in principle—explain this lack of exact predictive power. First, their sensitivity to initial conditions builds practical unpredictability into complex systems thanks to the cascading effects of minuscule measurement errors. Second, some highly complex systems create new possibilities of behavior as they go along [...] Radical systemic changes in such systems can be examined only after the fact, and no improvement in measuring accuracy can affect such radical unpredictability, because of the creation of new basic laws at 'emergent' levels [...] Reductionism is impossible [...] for analysis and then the aggregation of unit behaviors is in principle unable to account for emergent effects.

Central to complexity theory is the concept of emergence that addresses the relationship between different levels, to address the potential problem of reductionism to either the individual or higher level of the system. The emergent approach constitutes a fundamental rejection of the reductionism found in many types of natural and social sciences that favor managerialist megaprojects. The inherent emergence features syncs with open systems as opposed to closed systems that operate on a reductionist framework.

Rather than a simple hierarchical or nested relationship, complex adaptive systems coevolve and mutually adapt during the process. The conceptualization of the process of mutual adaptation is crucial to the theorization of the mutual constitution of complex inequalities that is so important for the analysis of intersectionality.

Empirical Manifestation of Complexity-Driven Mega-Projects (Hydro Dams)

In terms of the empirical features of complexity-oriented mega projects such as hydro-dams, the following provides an insightful viewpoint. Flyvbjerg (2006) posits that Megaprojects are inherently risky due to long planning horizons and complex interfaces. Also, such projects are led by planners and managers without deep domain experience, and these personnel may change repeatedly throughout the long project cycles that apply to megaprojects, leaving leadership weak. Judging by the three dams in Ghana, technical planners and engineers were the main drivers in tandem with the policy architects in government. As noted by Aaltonen and Kujala (2010) and Darko et al. (2019) the decision-making, planning, and management are typically multi-actor processes involving multiple stakeholders, public and private, with conflicting interests. Indeed, these processes have their specific relational imbalances that tend to mute significant voices, ideas, and priorities. This is evidenced by the many years of prioritization of energy generation to the disproportionate interest in the critical issues of the environmental, ecological, and resettlement ramifications of the dams. A sequel to this residual interest in the environmental and resettlement dynamics is the often inordinate commitment to aspects of the project concept from the outset. This has the tendency to foreclose or weaken alternatives.

Additionally, the turn to the development infrastructure era since the 1960s (early post-independence era) in many countries in the global South has allegedly been undermined by corruption. Indeed, Stiglitz (1989), Flyvbjerg (2009), and Moyo (2010) aver that due to the large sums of money required for megaprojects, such projects are imbued with the principal-agents problem and rent-seeking behavior. Given the inadequacy of technical expertise and unforeseeable contingencies or exigencies, hydro dams would require changes in the projected scope and scale over time. Indeed, all three dams had to go through significant changes before completion. We argue that given the complex and non-hierarchical nature of the relations amongst the WEF, the pursuit of dominant institutional control is most likely to have a disequilibria effect on other components of the nexus. Hausermann (2018) notes in the study of the Bui Dam, the absolute WEF-related resources adversely impacted the non-energy sectors of the nexus.

Taleb (2010) notes that the delivery processes of such megaprojects embody both high risk and statistically stochastic activities that make accurate prediction difficult. The net effect is that managers with a clockwise mindset or Newtonian positivist orientation barely have control over the outcomes. Flyvbjerg (2018) notes is that there is statistical evidence demonstrating that such complexity and unanticipated events are mostly not accounted for. Arguably, the unanticipated cost and design variations of the Bui Dam from project inception to completion affirms this unpredictability. Furthermore, the peculiar financial resource constraints in many of the African economies, for instance, such a practice makes budget and time contingencies grossly inadequate. Finally, the information asymmetry germane to megaprojects creates room for misinformation; such misinformation about costs, schedules, benefits, and risks is the norm throughout project development and the decision-making process. The net effect is the hackneyed cost overruns, delays, and benefit shortfalls of the operations.

Indeed, a nascent growing body of studies on complex system behavior illustrates not only the unpredictability of such systems but also provides ideas, such as feedback loops, tipping points, and regime shifts, that spark legitimate concern about the unintended consequences of management actions and inactions. As a result, static indicators of environmental and ecological change are increasingly viewed as insufficient to understand the impacts of evolving boundary conditions (Jackson et al.,

FIGURE 1 | Map of Ghana showing the Bui Dam location. Source: http://facultyexchangeghana.blogspot.com/2014/03/ghanas-infrastructure-electricity.html, March 2022.

2009). Importantly, the deep and evolving understanding of the dynamic relationships between social, economic, cultural, demographic, environmental, and climatic phenomena is now considered as key to making appropriate complex management decisions (Sidle et al., 2013; Gillson and Marchant, 2014). Consequently, the integrated study of coupled social-ecological systems (Liu et al., 2007) is viewed as the dominant framework for the management of complex ecosystems. However, this essential integrative cross-sectoral governing mechanisms and practices of a WEF project is deficient in many developing countries (Liu et al., 2018).

BACKGROUND TO BUI DAM AND METHODOLOGY

The Bui dam is within the moist semi-deciduous forest and the Guinea Savannah woodland vegetation zones. There is the Bui National Park (BNP) and Bui Forest Reserve in the catchment area of the dam. Wildlife such as monkeys, deer, hippopotamus, and antelopes abound in BNP. The combination of the vegetation zones permits the cultivation of a variety of cereal crops, tubers, and vegetables, and the rearing of animals (Appiah et al., 2017). The mean annual rainfall is between 1,140 and 1,270 mm—a double maxima rainfall regime.

The Bui dam (**Figures 1**, **2**) was constructed at the Bui Gorge on the Black Volta, located on the borders of the Northern and Brong-Ahafo regions, and the southern end of the Bui National Park (Darko et al., 2019). Besides Akosombo was constructed in 1966 and Kpong in 1982, the Bui dam is one of three hydroelectric dams in 2013 in Ghana. The towns/villages affected by the construction of Bui are Brewohodi, Dam site, Agbegikuro, Lucene, Bui village, Bator/Akanyakrom, and Dokokyina (Appiah et al., 2017). Its reservoir has a surface area of 444 km^2 (at a maximum operating level of 185 m amsl) and at minimum operating level of 167 m amsl (Gyau-Boakye, 2001; Darko et al., 2019). The water reserve, besides serving as hydropower generation, is supposed to serve as a source of irrigation. Bui hydroelectric power is the second-largest hydroelectric plant after the Akosombo. The construction of the Bui (2008–2013) belongs to the second phase of large dam construction in Africa and it is an excellent case study for understanding the contested nature of

FIGURE 2 | Bui Dam in Ghana (taken by Owusu-Abedi in 2015).

dam projects since the initial dam schemes in the 1960s (Gocking, 2020). Though the droughts in the 1980s that affected Akosombo and Kpong's power supply negatively affected the development of Bui dam, the need to diversify Ghana's energy sources, the readiness of China to fund some of these projects, and discourses around the climate that characterized thermal energy projects have brought the Bui dam project to the fore.

In terms of the methodological approach, this paper relies primarily on secondary data. The chapter entails an extensive review of relevant literature on the water-energy-food nexus and policy documents on Ghana. We critically identify themes and how they relate to understanding how the WEF applies to the Bui dam project.

BUI DAM IN GHANA ENERGY DEVELOPMENT CONTEXT

Energy is fundamental for the global economy by providing power for socio-economic activities. Energy can come from renewable and non-renewable sources. As a source of energy, hydro dams play a critical role in global energy provision, accounting for about a quarter of global energy. In Africa, hydro dams have contributed to the energy needs of the continent over the past 50 years. Countries have built energy resources, including dams, to drive their socio-economic development. Since the 1960s, Ghana has made efforts to increase its installed energy capacity. Ghana currently has about 4,399 MW installed capacity.

TABLE 1 | Types of energy sources in Ghana.

Energy source (MW)	Hydro	Thermal	Renewable	Total
Akosombo	1,020			1,020
Kpong	160			160
Bui	400			400
Takoradi aboadze plants		550		550
Sunon-asogli power		200		200
Tema thermal power plants 1 and 2		159.5		159.5
Mines reserve diesel plant		80		80
Ameri power plant		550		550
Other THERMAL PLANTS		1256.5		1256.5
Renewable			2.5	
Total	1,580	2796	2.5	4,399

Source(s): Energy Commission (2012) and Obour et al. (2016).

This comprises 1,580 MW hydro, 2,796 MW thermal, and 2.5 MW renewable energy (see **Table 1**). The hydro energy sources are Akosombo, Kpong, Bui (Obour et al., 2016).

These three hydropower dams constitute 54% of Ghana's total installed electricity generating capacity (Gocking, 2020). Though Akosombo and Kpong dams are purposely constructed for power generation, they provide some auxiliary services, including water for fish farming and agriculture along the banks. Bui is supposed to serve as a multi-purpose dam, providing energy, irrigation

facilities, and a city. For national development, hydropower is cheaper but fluctuations in hydrology and weather, and dilapidated infrastructure, inhibit the ability to produce the estimated power. Thermal power sources such as the Takoradi Aboadze, Sunon-Asogli, Tema Thermal 1&2, Mines Reserve Plants, and Ameri Power Plant complement the hydropower. The thermal plants have become important players in Ghana's energy mix, although mostly supplied by private sector actors while the state provides the quarantined market.

The Bui dam, with an installed capacity of 400 MW is the second-largest hydropower dam in Ghana after Akosombo. Its construction started in 2008 and was completed in 2013 with funding from the Chinese government. The 2007 power challenges experienced in Ghana partly reignited the need to build Bui after being on the drawing table since the 1920s. Bui is supposed to be Ghana's first multi-purpose dam, operating along the water-energy-food (WEF) nexus. It has three components: hydroelectric power; the water reservoir for irrigation; and the Bui settlement (Bui city) (Appiah et al., 2017). Despite the plan that Bui will generate about 400 MW, (22% of Ghana's hydropower at the time), it barely generates half of its estimated capacity (185 MW) due to rainfall variabilities and technical challenges. It seems Ghana has underestimated the transboundary management system of the Volta River where activities in Burkina Faso and other areas negatively affect the water supply into the dam.

The Bui dam is supposed to provide power and commercialized agriculture through irrigation. As witnessed across the globe, dams provide services and benefits such as hydropower, creation of waterways, flood control, and provision of water for agricultural activities, mostly for drought-prone areas and commercial purposes (World Commission on Dams, 2000; Biswas, 2012; Obour et al., 2016). Energy is very fundamental to socio-economic development, especially industrial and agricultural development. Thus, synergies between energy and water/irrigation are critical for sustainable socio-economic development and Ghana's structural transformation. Efforts at promoting irrigation agriculture cannot be done without energy. This raises issues of coordination, collaboration, and synergies among water, energy, and food (irrigation) in Ghana within the WEF framework.

IRRIGATION PROSPECTS OF BUI: CONCEPTUALIZATION AND IMPLEMENTATION DEFICIENCIES

Less than 2% of Ghana's cultivated land is irrigated. Since agriculture is the mainstay of Ghana's economy, the main source of gross domestic product (GDP) and employment, various efforts have been made to move it from being purely rain-fed to utilizing small- and large-scale irrigation. There have been plans to irrigate the Accra plains for rice production. The Tono and Vea irrigation dams in the Upper East Region are a few of the functional irrigation projects in Ghana (Agodzo et al., 2014) despite the challenges associated with them. Tono Dam (1775–1985) is located in the Kassena-Nankana district of the Upper West Region. The 2 km dam irrigates 2,490 hectares of land in the production of rice, soya beans, and tomatoes. Vea dam in the Bongo district is a multi-purpose dam for crop, fish, and livestock production, and domestic water supply. There are over 380 small to medium reservoirs in the five northern regions for various irrigation activities and livestock rearing. Recently, commercial irrigation activities are springing up near some water bodies in Ghana for the growing fruits and horticultural crops for export (Agodzo et al., 2014). The "one-village-one-dam" project that is being championed by the New Patriotic Party (NPP) is supposed to increase the number of dams in the northern part of Ghana. Ampadu et al. (2015) recently argued that the Vea dam has led to improvement in living conditions, but at the same time resulted in the relocation of 34% of communities in the area. Thus, dams can have mixed impacts. Irrigation projects are aimed at tackling issues of industrialization, poverty reduction, food security, and ecological sustainability.

Over the years, Ghana's irrigation development efforts seemed to have been less successful. Bui dam is one of the latest efforts to develop all-year-round crop cultivation via irrigation. The dam is to serve two purposes: energy and irrigation. Even though Bui is purposely designed for hydropower, it includes the development of a 30,000-ha irrigation scheme for agricultural development, providing opportunities for enhanced eco-tourism and fisheries (Hensengerth, 2011; Darko et al., 2019). The Bui irrigation scheme is to expand agricultural production to improve food security (BPA, 2011; Boateng, 2014; Obour et al., 2016). Bui is unique since it is supposed to have learned from the mistakes of the Akosombo and Kpong dam projects. Among the large hydropower dams in Ghana, 3,000 ha have been developed presently under the Kpong irrigation project. Akosombo dam has some lakeshore irrigation schemes along the lake, covering 400 ha which was developed after the building of the dam. These two projects were an afterthought since the energy component was the main driver. In the case of Bui, it is supposed to be anchored on the water-energy-food nexus. More importantly, the irrigation component is supposed to turn the Bui dam enclave into an agriculture hub and a "Bui city."

Within the WEF framework, the Volta River Authority (VRA) is supposed to lead the energy generation while at the same time coordinating with other agencies to lead the irrigation development in the Bui and its enclave. Some of the agencies that should be involved in the irrigation aspect of the Bui dam project are the Ministry of Food Agriculture (MOFA), the Ghana Irrigation Development Authority (GIDA), Land Commission (LC), Centre for Scientific and Industrial Research (CSIR), Water Resources Commission (WRC), and others. These agencies are supposed to work in tandem to promote irrigation development. The GIDA, established by law in 1977, is to oversee all irrigation-related development activities in Ghana (Agodzo et al., 2014), including being actively involved in the irrigation component of the Bui dam project. Bui is one of the largest multi-purpose hydraulic structures in Ghana presently (Pwalugu, another multi-purpose dam, is supposed to be built very soon)—generating hydropower and supporting irrigation. Presently about 5,000 hectares of irrigatable land is to be developed under Bui, with possibilities of expansion. The GIDA has not seemed to

be fully involved in the planning and implementation of Bui so far. This raises questions about the conceptualization and operationalization of the Bui irrigation projects.

Based on the literature on Bui and how the dam has operated over the past eight years, Bui seems to have conceptualization and operationalization deficiencies. Conceptually, it was assumed the weather and technical conditions and various actors will cooperate seamlessly to promote the development and functioning of Bui. However, it seems the weather and technical viability have been overestimated since the anticipated maximum water level has not been achieved. The transboundary nature of the Volta River management systems and how the activities of the Bagre dam constructed in 1992 in Burkina Faso could affect development in Ghana was not been taken sufficiently seriously. Okyereh et al. (2019) recently applied the Water Evaluation and Planning (WEAP) tool to simulate the operations of the Bui hydropower scheme and downstream competing water uses. The results show that while for domestic and livestock water demands, there will be enough water supply to meet demand between 2013 and 2030, the planned Bui irrigation scheme will suffer. In order to have enough water for a sustainable irrigation project downstream, comprehensive water supply management is needed (Okyereh et al., 2019).

With regards to the implementation of the Bui irrigation project, the assumption of seamless coordination among the various actors and agencies has been problematic. The Bui project is anchored on power, led by Bui Power Authority (BPA) similar to VRA, instead of having the GIDA heavily involved in the irrigation project since agriculture viability and importance economically is critical in terms of Bui. Bui is managed by BPA, responsible for the day-to-day operation of the dam. Nexus works in two forms, either there is a coordinating agency or different agencies work together to achieve a specific goal. The BPA has assumed the former, coordinating the operationalization of the water-energy-food (WEF). Thus, given that BPA cannot perform all the functions, a multi-sectoral approach is needed. This will require agencies and actors from water, energy, and food (agriculture) spaces to work together to operationalize the Bui vision. This is where the notion of nexus comes into play. The implementation processes should critically consider role conflicts, coordination failures, and resource allocation/distribution in the operations and functions of the varied actors. Given Bui's vision is to move beyond the traditional notion of the construction of hydropower dams to a multi-purpose one for irrigation and fisheries, we have to examine the politics, discourses, actions, policies, and practices of various actors and how interactions among them shape development outcomes.

Poor coordination of policies and decisions of the proposed Bui irrigation project. Water features prominently in the key strategies driving the country's economic growth and development, such as Ghana's Shared Growth and Development Agenda 2014–2017. Ghana has a comprehensive policy and regulatory framework for water resource management and investments, under the umbrella of the 2007 National Water Policy (Mosello et al., 2017). But how does Bui Power Authority coordinate with other agencies and actors within the water space to promote irrigation has been confronted with challenges? BPA appears to be saying "I can do it all," repeating the mistakes of VRA where the authority monopolizes all its activities, thereby affecting its ability to deliver other services effectively besides the power.

The politics of irrigation development of Bui, just like any nexus-driven scheme, is complex. There are technical and political motives and actions that drive irrigation development (Mitchell, 2002). There can be a turf war between institutions like the BPA, GIDA, and MoFA who are supposed to drive the implementation of the project. BPA has assumed the overall management of all aspects of the Bui dam project, including irrigation instead of being the coordinating authority with other agencies and institutions such as the MoFA, GIDA, and WRC who are more knowledgeable in some of these areas to get involved in the implementation. In Ghana, when comes to state lands, it is the Land Commission that facilitates the acquisition of land on behalf of the government for its projects. But in the preparation of the executive instrument for the land acquisition for Bui, BPA was heavily involved (Adu-Gyamfi, 2015). There is no evidence that the Land Commission has been involved in acquiring further land for the main irrigation project and the resettlement of the few communities stipulated in the Bui dam project. Furthermore, an interview with a key informant from the Irrigation Development Authority is quite revealing: "We were not engaged in the project planning, appraisal, formulation and implementation of the irrigation scheme. From the outset, the BPA set itself to manage it on their own. Obviously, one would have thought that the high magnitude of the project would necessarily and actively involve us; in view of our statutory national mandate for irrigation development." Indeed, one wonders the experiential and institutional capabilities of the BPA to undertake this lofty project in the wake of its inherent challenges relative to energy generation. It bears noting that irrigation development in Ghana has witnessed a low-key investment, especially in relation to budgetary, technical, and logistical support (Owusu-Baah, 2008). Given these prior challenges, it is legitimate to question the capacity of the BPA to undertake this novel irrigation project. There is a turf war between and among implementing agencies. In trying to implement the activities as outlined in the master plan, including the irrigation component of the Bui dam project, there are different agencies and actors in the space that should be assisting BPA, but due to lack of clarity in functions among the agencies, there are role conflicts, with some agencies doing things they are not good at just because of the political sway they have. For example, the BPA is implementing the irrigation project which is supposed to be supervised by the Ministry of Food and Agriculture (MoFA) and the Ghana Irrigation Authority (GIA).

The private sector investors are supposed to be involved in the Bui irrigation project. Given that agriculture is a high-risk business, there is no evidence that apart from in the grand scheme outlined during the design of the project, the private sector has not come on board the Bui project yet. There are uncertainties in water investment decisions amidst climate change, investment priorities, and sustainable development, hence the need for

MoFA and GIA to be actively involved since they have the technical knowledge in such areas.

There is a grand scheme for a "Bui City" to be built as part of the dam project. But in the actual implementation, most of the money is devoted to the construction phase and not necessarily to the operationalization of the other parts of the dam project. In the initial Bui resettlement programs, the MoFA provided support to affected people through the supply of seedlings, fertilizers, insecticides, and the extension services and other assistance (Adu-Gyamfi, 2015). MoFA role regarding irrigation in the irrigation project has seemed to be lost.

Calls for inter-disciplinarity and trans-disciplinarity are crucially timely. This is against the backdrop of the failed multidisciplinary foundational and technical disciplines that have enjoyed a high degree of dominance in decision-making. Indeed, the complexity of the intricate structures and systems WEF justifies a well-balanced inter-disciplinary approach at every plausible component of WEF. Thus, vital wide-ranging issues/factors/elements from conceptualization, cost-benefit analysis, monitoring, evaluation, implementation processes as well as vital exogenous factors must be grounded in a cohesive evolving inter-disciplinarity. It bears noting that each component of the WEF accommodates an incredible diversity of systems, structures, interests, and power relations that cannot be understood by reductive quantitative bias disciplines. For instance, the agriculture sector in Ghana is nested with a plethora of competing interests between commercial and peasant farmers, the land tenure crisis and the unresolved agrarian question is very prominent in Ghana's agriculture sector. Indeed, the ongoing land grabbing practices across sub-Saharan African economies may aggravate the land demands challenge of many peasants and small-holder farmers.

A cautionary tale is necessary when one considers WEF as a mega-project. There appears to be a sense of optimism bias by officialdom and other promoters who tend to water down the cost and highlight the assumed and/or imagined benefits. Policy narratives about the Bui Dam show positive dynamic linkages ranging from industrialization to poverty reduction similar to those of the Akosombo Dam. However, studies by Odoom (2017) and Yankson et al. (2018) suggest mixed outcomes. Currently, the energy generation capacity is way below the projected 440 mw and the irrigation system is far from realization. This outcome deficit is not surprising as it reflects what Flyvbjerg (2018) calls cost underestimation and outcome maximation. Indeed, doubts about the success of such mega-projects are widespread. Vickerman (2017, p. 401–402) posit the following:

> Positive wider impacts, where they exist, typically account for an additional 10–20% of benefits; Positive wider impacts are not guaranteed for every project. Where positive wider impacts do exist for some geographical regions they could be negative for others, reducing the aggregate effect; The common assumption is deeply problematic that wider benefits will come to the rescue of a project which is marginal on the basis of its direct benefits and costs; Only in "very particular cases" are wider benefits likely to rescue a project from non-viability; Wider impacts were never intended to be a cure for investment appraisals, especially marginal ones, but only a way to ensure completeness."

The nexus operates on an assumption of seamless collaborative relations among and between institutions, agencies, and actors in the policy and program implementation space. But in most cases, as with the Bui irrigation project, this is not the case. There are tensions, side-lining, and role conflicts among the actors.

The idea of agriculture development through the promotion of irrigation is one of the main unique features of the Bui dam project. A change in old hydroelectric power (HEP) narrative to a genuine multi-purpose paradigm calls for a better understanding of the nexus (water–energy–food–environment) system. Based on the technical and feasibility studies, it was assumed that once the Bui dam is constructed, the private sector will lead in the irrigation development. But given the weak nature of the private sector in Ghana and the risks associated with agriculture investment, it seems the Bui irrigation project was planned to fail. Obour et al. (2016), however, noted despite the improvement with respect of Bui dam in terms of compensation and resettlement, the agriculture services have to be improved by providing extension services and inputs to improve food security and the economic status of the local people. This also raises serious issues about which agencies are involved in the provision of agriculture services, and if there is coordination among the agencies and actors in the irrigation development space. The nexus discourse expects seeming coordination among the actors and agencies but does not account for the politics in how those agriculture services are provided.

According to the Bui Irrigation Scheme, by taking advantage of the reservoir, the projected irrigated land over 30,000 hectares would be the biggest in the country, and crops under consideration include but are not limited to maize, sorghum, yam, cassava, soya bean, pepper, cashew, sugar cane, cabbage, and tomatoes. Studies by Yankson et al. (2018) and Hausermann (2018) suggest that the output of these crops have not been satisfactory as the resettled farmers still face the co-variation risks of smallholder farmers, notably uncertainty/low yield, and price volatility. These co-variation risks, which are widespread in Ghana's agrarian sector, are produced by limited access to credit, the land tenure crisis, inadequate farm inputs, low yielding seed varieties, and limited extension services delivery, among others (Owusu-Baah, 2008).

Dam decisions go beyond technical to issues of politics. Decisions on the construction of a dam are not only technical, but it also involves politics of which actors and institutions do what and there are winners and losers in the outcome of the dam project. Darko et al. (2019) argue that looking at the experiences of dam construction, decision making on dams elicits a diverse array of actors with multiple interests and this creates indeterminate consequences. Focusing on the technical without examining social and environmental issues might lead to failure on the supposed purpose of the dam. Understanding the interface between water politics and large dams, on the one hand, and the quest for socio-economic development, on the other, enhances our analytical gaze to capture the nuances and complexities resulting from a diversity of actors and power relations, locally,

nationally, and transnationally that shape and condition the dam space and how the power politics influence which aspect of the dam is prioritized (Darko et al., 2019). Thus, the nexus discourse that seems to focus on technicality and linearity in the decisions concerning the dam might lead to failure.

CONCLUSION

Water, energy, and food are important for socio-economic (re)production. There are, however, complex relations among these resources as there are diverse actors and competing interests in those spaces in an attempt to utilize them in a more beneficial and sustainable manner. It is within this framework that the question of the WEF nexus arises. The quest for improving development challenges globally has brought development discourses and policy implementors to the idea of a "nexus"—connection(s) or linking two or more phenomena or variables to frame development policies and implementation. But sometimes we turn to dwell on the technical or instrumental aspects instead of understanding the complex relationships. The WEF nexus is prominently embedded in historical complex systems that tend to counter-balance the hyper-deductive projected costs and benefits. WEF is an embodiment of a complex system that helps us to understand the multi-level, contradictory, and diverse interests at play within, between, and across the systems. Yet, the conceptualization and implementation of specific WEF framed projects have been problematic since the assumption of seamless collaborative relations among and between institutions, agencies, and actors in the policy and program implementation space is far from the reality.

The Bui project in Ghana shows tensions, side-lining, and role conflicts among the actors, where the energy sector actors weigh power and resources over other institutions and actors in the space to drive the nexus. As noted above the Bui dam project which is supposed to produce energy while at the same time providing water for irrigation and other socio-economic benefits is not experiencing smooth implementation. In trying to implement the activities as outlined in the master plan of the Bui dam project, including energy production and irrigation, there are different agencies and actors in the space that should be assisting BPA. There are role conflicts, with some agencies doing things they might be not good at. BPA is leading the implementation of the irrigation project which should be supervised by MoFA and GIDA. Appiah et al. (2017) advocate that BPA in conjunction with the resettled communities and other agencies should ensure a sustainable livelihood and environmental resources management through dialogue and engagements. Even the irrigation project implementation is underpinned by lip service. It was envisaged that the Bui dam will lead to irrigation of about 5,000 ha through private sector participation with government support, but this has been done to date. A Dutch firm, Royal Haskoning BV, was engaged to undertake feasibility studies of Phase 1 of the irrigation project. More importantly, an interview with an official of the Bui Irrigation Scheme suggests that this first phase remains a work in progress with no completion date in sight.

There appears an unending institutional monism by the individual sectors where institutions and agencies in the irrigation and energy spaces act in silos. This path-dependent practice poses a bleak prospect of forging an organic/instrumental nexus where institutions and agencies collaborate the achieve specific goals. The age-long challenges in the independent sectors should have prepared a logical basis for a well-coordinated whole-of-system approach germane to WEF. Furthermore, it is imperative to understand that the various institutional arrangements have a unique mandate, budget cycles, priorities, norms, laws, rules, and methodological approaches. These specificities do not make institutional alignment and harmonization an easy task. These are more governance issues than merely reductive technical social engineering practice. More important is the issue of power differential among the diverse institutions relative to conceptualization and implementation of the Bui energy and irrigation project.

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.

AUTHOR CONTRIBUTIONS

PS and OT: responsible for conceptualization, drafting, and writing. Both authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

The authors would like to acknowledge the insightful comments from the reviewers and support of the Institute of African Studies (IAS), University of Ghana for the support.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.