THESIS

MUDDY STATE DEVELOPMENT IN GHANA'S UPPER EAST REGION:

ONE VILLAGE, ONE DAM, AND ITS EFFECTS ON SMALLHOLDER FARMERS IN A STUDY COMMUNITY

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ABSTRACT

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Warming trends and drought conditions across northern Ghana portend major implications for water access critical to the future of smallholder farming, food security, and human health. To mediate the impacts of future water resource concerns, the Ghanaian government launched the *One Village, One Dam* initiative (1V1D) in 2017 which aimed to construct or repair approximately 570 small-scale dams on ephemeral streams in northern communities. Hundreds of dams have been constructed or overhauled to *develop* northern regions and provide communities with access to water, particularly for dry season farming. This thesis examines the implications of the 1V1D intervention in one study community in Ghana's Upper East Region including social-ecological relationships between smallholders and their farming practices, land-use changes, gold mining, climate data, and farmer perceptions of climate change. My findings reveal that while the government attempted a community-based approach with 1V1D, local insight was marginalized and implementation relied more on outside engineering expertise and State preferences. Most participants contend the dam embankment was poorly designed, improperly located for adequate water capture, and heavy sedimentation including from gold mining is decreasing its capacity. The dam is insufficient for dry season farming, forcing farmers and livestock to depend on wells and boreholes for water, and regional markets for supplemental food supply. Issues of food, water, and economic insecurity are therefore not well addressed by this State development project. A comparative analysis of participant perceptions on climate change is explored and this thesis ends with insights on community ideas for more sustainable climate adaptation interventions.

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TABLE OF CONTENTS

1 INTRODUCTION

Climate change portends variegated impacts for smallholder agriculturalists with important implications for food security (Baffour-Ata et al., 2021; Kumasi et al., 2019), human and ecosystem health (Antwi-Agyei et al., 2018; Black et al., 2011), adaptation (Baffour-Ata et al., 2021; Black et al., 2011; Kumasi et al., 2019; Nyantakyi-Frimpong, 2020), and human migration (Hunter et al., 2015; Mohammed et al., 2021). While global warming may decrease agricultural yields in drought-prone areas, many farms are also vulnerable to flooding (Kumasi et al., 2019; Mohammed et al., 2021). Due to social-ecological complexity, the implications of climate change for smallholder agriculturalists hinge on intersecting ecological, cultural, geographic, and sociopolitical interactions (Amadou et al., 2015; Antwi-Agyei et al., 2018; Meze-Hausken, 2004).

Sub-Saharan Africa is one of the most vulnerable regions to climate change due to poverty, extensive agrarian-based livelihoods, and food and water insecurity (Antwi-Agyei et al., 2018; Baffour-Ata et al., 2021; Kumasi et al., 2019; Niang et al., 2014). Within the continent, northern Ghana is a critical area of concern due to its long and discriminatory colonial and post-colonial policies (Amadou et al., 2015), which has led to underdevelopment, precarious agricultural livelihoods, food insecurity, and seasonal or permanent migration (Antwi-Agyei et al., 2018; Kumasi et al., 2019; Mohammed et al., 2021). In the semi-arid northern regions of Ghana, about 73% of households are smallholder farmers (Mohammed et al., 2021). Continued soil degradation, warming temperatures, and less predictable precipitation also create challenging conditions for rural farmers in Ghana's northern regions (Antwi-Agyei et al., 2018; Mohammed et al., 2021).

Adding to water concerns is the lack of irrigation development; Ghana's arable land is only about 3% irrigated (Asare-Nuamah & Botchway, 2019) and smallholders heavily rely on rainfed

agriculture. Still, rural farmers have creatively maintained production through adoption of new crops (Amadou et al., 2015), innovative agroecological practices, dams (Hunter, 2003), and diverse livelihoods that include seasonal and permanent migration (Antwi-Agyei et al., 2014; Baffour-Ata et al., 2021; Kumasi et al., 2019; Mohammed et al., 2021). As of 2016, smallholder farmers in Ghana were responsible for 80% of the country's food production (Asare-Nuamah & Botchway, 2019) despite limited access to meteorological data (Amadou et al., 2015), agroecological challenges including access to agrochemical inputs, underdevelopment, and changing climate conditions (Amadou et al., 2015; Antwi-Agyei et al., 2018; Baffour-Ata et al.). In the midst of these challenges, development interventions by various actors (NGOs, the State, philanthropists, etc.) seek to improve and develop landscapes and smallholders through various interactions (Li, 2007). It is in these conditions that the everyday smallholder farmers persist.

1.1 Development and Political Ecology

> Modernity's ability to provide solutions to modern problems has been increasingly compromised … there are no modern solutions to many of today's problems … with massive displacement and ecological destruction, but also with development's inability to fulfil its promise of a minimum well-being for the world's people. (Escobar, 2004: p. 210)

Development theory and interventions have taken many forms over history. While a deep dive into development theory is beyond the scope of this thesis, I lean on James Ferguson's (1997) summation of development theory and the deep embeddedness of western ideologies of progress. Ferguson (1997) notes that early development theory focused heavily on stages of human evolution imposed by white European and American social scientists postulating white dominance over "savage" or "barbaric" peoples who were "less evolved" on a linear trajectory toward Eurocentric ideologies of civilization. In effect, development theory focuses on a modernizing and ubiquitous universality and

social regulation (McMichael & Morarji, 2010) in which “all world cultures and societies are reduced to being a manifestation of European culture” (Escobar, 2004: p 213).

Political ecological thinking began in the 1980s facilitated by deep understandings of unequal power dynamics in social and environmental relations (Ulloa, 2020). Political ecology examines unromanticized histories, constructed spaces, and the production of knowledge that have generated inequitable interactions between groups of people, and between people and their environments (Perreault et al., 2020). Political ecology research unpacks unevenness in the global economy, linking development of western countries to underdevelopment and resource exploitation of non-western countries (Acheampong, 2020). Ulloa (2020: p. 323) notes that it has “criticized development as a discourse of modernization … that the logic of hegemonic globalization and economic development have generated environmental degradation, giving rise to new proposals for relationships with nature and space.” Moreover, narratives and justifications for modernizing development are further exacerbated by western self-interests, binary categorizations and over-simplifications (Scott, 1998), nationalistic fear mongering of a looming climate migrant crisis (Black et al., 2011), environmental determinism (Peet, 1985), and metrics for human progress (McMichael, 2010a).

In an era where climate change presents one of the biggest threats to natural and social systems, modernization development and interventions have further crystalized as technocratic solutions to social and environmental problems. This is particularly true in smallholder agricultural development where modernization is played out through the global distribution of agrochemicals, enhanced, foreign, and cash crops, introduction of new farming techniques, conservation and land management, and foreign infrastructure (Li, 2015). Despite sometimes good intentions, modernization can perpetuate uneven modes of power against smallholders (Li, 2005; Scott, 1998) that political ecology is positioned to examine.

As a result of hegemonic globalization, rural land-users, governments, and intergovernmental organizations are working to adapt to and mitigate climate change impacts around the world and across sub-Saharan Africa (Kleemann et al., 2017; Mohammed et al., 2021, United Nations Department of Economic and Social Affairs, 2015) with varying degrees of success. Yet, significant questions arise when modernist State leadership promotes western-derived climate change interventions to improve the well-being of non-western citizens, especially if they do not consider local solutions. Local communities should not be left behind but rather their knowledge should be incorporated into research and planning to develop solutions to sustainably improve the long-term well-being of "development" beneficiaries (McMichael, 2010b).

For example, the so-called *New Green Revolution* occurring in regions such as Africa, and Ghana specifically, is at risk of developing and industrializing based in western ideologies eliminating traditional and often successful agricultural practices in favor of foreign globalized dependency and further social-ecological ruin (Holt-Giménez & Shattuck, 2009). Ghana's northern regions have long histories of underdevelopment, food insecurity, and out-migration (Antwi-Agyei et al., 2018; Kumasi et al., 2019; Mohammed et al., 2021). This is coupled with deteriorating agricultural and climate conditions for rural farmers (Antwi-Agyei et al., 2018; Mohammed et al., 2021), and declining economic and social well-being (Acheampong, 2020). As seen in much of post-colonial Africa, Ghana's long histories rooted in British colonial policy and law are solidified by post-colonial north-south migration patterns (Van der Geest, 2011), natural resource management (Dinko & Nyantakyi-Frimpong, 2022) and uneven development in the modern era (Acheampong, 2020; Nyantakyi-Frimpong & Bezner Kerr, 2017). Not only was Ghana a key site of capture and transportation of enslaved people during the Transatlantic Slave Trade, but the country continues to be heavily involved in neoliberal reform (i.e., development and intervention) by foreign State agencies since the 1980s, which has weakened the State and focused industries on natural resource extraction (Robbins et al., 2014) and accumulation by dispossession

(Ayelazuno, 2014). This is recently concerning as Ghana's inflation rate reached 40% in late 2022 and the State is considering further austerity measures required by International Monetary Fund lending schemes (Naadi, 2022).

Development is thus an applied issue and the interdisciplinarity of political ecology is well-suited to examine interventionists' contemporary sentiment of how *less developed* societies *become modern*. The non-uniformity of society and social-environmental relations should inspire inclusivity and humility-driven development practices, and yet power inequities expectedly prevail in development discourse (McMichael, 2010b). Contextualizing the domineering histories of western imperialism and colonialism in *less developed* areas, followed by a revolving door of extraction and machinations of modernizing political and economic supremacy, it is no surprise that development inertia favors wealthier powers in the global arena (Acheampong, 2020). Furthermore, the negative effects of climate change are expected to be felt more by those whose precariousness has been *produced* by these histories (Robbins et al., 2014).

1.2 Dams as Development

Dam projects have been an integral part of development in the twentieth century (Gwazani et al., 2012). They have been promoted for their ability to improve economic well-being (Akhter, 2015; Tucker Lima et al., 2016), agricultural yields and irrigation (Hausermann, 2018), cohesive nation building and technocratic modernization (Akhter, 2022), electrification, and resilience to climate change (Gwazani, 2012). Some dam projects are promoted as universal solutions to political, social, and environmental issues using controversial and nationalizing rhetoric to modernize (i.e., develop), yet with negative outcomes for people and ecosystem function (Akhter, 2022; Cole et al., 2014; Hausermann, 2018; Tucker Lima et al., 2016).

Still, as the global push for energy consumption increases and the effects of climate change alter water access, dams can also have negative ecological and social consequences (Fearnside, 2015; Tucker Lima et al., 2016; Gwazani et al., 2012). At the smaller scale, they have long been constructed by natural phenomena and ecosystem engineers such as beavers in North America, Europe, and Asia with important effects to vegetation, fish and wildlife, sediment and flood control, and water management (Pilliod et al., 2018). On the other end of the scale, dams can cause intense environmental degradation inundating extensive areas with water (Fearnside, 2015), altering nutrient and sediment loads (Assahira et al., 2017; Forsberg et al., 2017), causing deleterious effects to ecological community composition (Tucker Lima et al., 2016; Resende et al., 2020) including species loss and extinction (Rocha et al., 2019), and altering local or regional climates (Sun et al., 2021).

Further, dams of scale and the institutions that implement them are associated with extensive population displacement, dispossession of farmland and loss of other economic livelihoods, food insecurity, negative health outcomes, and exclusion of dam benefits (Hausermann, 2018). Dam projects throughout the tropics have villainized oppositionists, especially Indigenous populations, and include human rights violations, violence (Tófoli et al., 2017), and even murder (Fearnside, 2015). Thus, it is clear that there is an inherent connection between the politics and development of dams, and the social and ecological systems in which they are integrated.

Though, even when well-planned and welcomed by community members, dam projects are not always sufficient to offset the diverse causes of human or ecological vulnerability. At its most basic level, a dam must safely capture and moderate water for various uses as a natural resource. But their success to improve water availability can be just as frequent as the rains that feed them, saying nothing of the hydrological risks to communities and ecosystems above and below dam structures (Tófoli et al., 2017) or other social-ecological implications. Unequal water access, water quality concerns including microbiological, siltation, increased salinity caused by increasing evaporative demand, and management

and upkeep costs are of constant concern (Ritchie et al., 2021). Those closest to the dam or capture would expectedly have the greatest water access and reap the positive net impacts most, presuming water quality and health risks are minimal (Ersado, 2005). Still, Dinko et al. (2019) describe complex social and power relations that dictate other designations of access to water resources. Power imbalances for limited resources risks capitalistic development individualizing resource-use rather than preserving communally-oriented benefits of an essential resource (Esteva et al., 2013).

1.3 One Village One Dam Initiative

The Ghanaian State implemented the *One Village, One Dam* (1V1D) initiative in 2017 which set to construct or repair 570 small-scale water impoundment structures (henceforth known as dams) along mainly ephemeral streams in northern villages (Feed the future, n.d.; Nartey, 2022). The initiative corresponded with the election of President Nana Akufo-Addo of the New Patriotic Party (NPP) in 2016 who aimed to develop the North. There is much speculation that Nana's focus on northern Ghana was for political reasons, including that northern regions are severely underdeveloped (Mohammed et al., 2021) and have traditionally voted for the opposition, the National Democratic Congress (PeaceFmOnline, 2020a; 2020b; 2020c).

With oversight from the (now-defunct) Ministry of Special Development Initiatives (MSDI), the 1V1D is part of a series of State development projects including *One District One Factory*, *One District One Warehouse,* and *One Constituency One Ambulance.* Now run by the presidency with unchanged goals, 1V1D is a State attempt to provide impound water for northern rural smallholder farmers and was justified through discourses of improving food and water security, crop yields, socioeconomic well-being, and reduced rural-to-urban and seasonal migration (Asamoah, 2019; Smith, 2019). Yet limited literature, news reports, and public conversations suggest the 1V1D initiative is extremely varied in technology, public opinion, and roll out. While the Ghanaian government did not explicitly connect 1V1D

to climate *change* discourses and trends, State officials clearly identified the need to provide water to arid farming systems in the northern regions (Feed the Future, n.d.).

1.4 Research Questions

This thesis explores the relationships between the implementation of the 1V1D development initiative at a single field site and unexpected social-ecological impacts linked to the dam. Specifically, this study focused on three primary questions:

1. *How do local community members understand and use the newly constructed dam?*
2. *What are the social and environmental effects linked to the dam and how is the dam impacting nearby farming practices?*
3. *How does the mission of the 1V1D to improve water security articulate with local climate data and farmer perceptions of climate change?*

To address these questions, this study employed field work and mixed methods including interviews and thematic analysis, historical meteorological data analysis, and a review of the literature.

2 LITERATURE REVIEW

2.1 Modernization, State-led Development, and Unexpected Social-ecological Impacts

Modern State intervention occurs in contexts of globalization and international development institutions like the World Bank and International Monetary Fund, which have problematic histories of authoritarianism and corruption, short-sightedness, and privileging corporate interests (Nega & Schneider, 2014). Like most environmental issues, intervention does not operate equally across space and is subject to the dynamic nature of interacting ecological and social systems (Zimmerer & Bassett, 2003). To bridge these systems and the issues therein, scientists can lean on critical analyses and transdisciplinary collaboration by well-versed researchers (Vitousek et al., 1997). Political ecology discourse contends that "the ecological modernization view is based on awareness of the legal, institutional, and eco-industrial and technomanagerial reforms, such as laws for water and air pollution control, that have led, in varying degrees, to improvements in environmental quality" (Zimmerer & Basset, 2003 p. 4).

And yet, rural agriculture in Africa has been widely discriminated against favoring urban over rural development since at least the 1970s (Bezemer & Headey, 2008). Due to the widespread Statehood movement of African nations in the 20th-century, it is pertinent to remember the lasting effects of colonialism and post-colonialism on affected African nations. Like colonial States of the past, even modern State development make complex landscapes and people *legible* through interventions that simplify, classify, and provide technocratic solutions to complex social and ecological conditions (Mitchell, 2002; Scott, 1998). For instance, in the mid-1960s, Tanzania's new government began coercively relocating millions of rural peasants in a social villagization project (*ujamaa)* expecting unreasonably high agricultural yields on unsuitable and unfamiliar lands (Scott, 1998). State

development of socio-agricultural production was rooted in top-down, unifying, and modernizing ideology, yet led to widespread famine and ecological devastation (Scott, 1998; Wisner, 2020) because social-ecological interconnections were not made priority. In a similar example, Wisner (2020, p. 55) notes an ecological, economic, and political *triple marginalization* of post-colonial Kenyans where politically disconnected groups were not only relegated to ecological hardship through migration to unfavorable land, but further deprived of economic development in ensuing years.

Despite separate development of social and ecological discourses and theory, social-ecological researchers since the 1980s have bridged knowledge and language gaps between sciences viewing their mutually embedded relations as coproducing across many disciplines (Ostrom, 2009). I echo Berkes' (2017) purposeful use of *social-ecological* verbiage to identify equal importance of both components of the system. Social (human) and ecological (biophysical) subsystems mutually and interdependently function in a complex performance of adaptation, development, integration, and reliance to make up the system as a whole (Berkes, 2017).

I draw on a critique of ecological modernization theory not only for its prevalence in environmental change solutions, including at my field site, but also because of its implementation at both large and small scales. Large-scale, small dam projects such as is the focus of my research have been used in Ghana before (Hunter, 2003). Poor implementation by the State, uninvested corporate stakeholders designing and constructing infrastructure, and performative engagement with local stakeholders by top-down institutions has led to obvious failures in development outcomes (Hunter, 2003). It is not, perhaps, the end product of a development project, but rather, the implementation, process, and consequences of its edifice that require the most scrutiny for us to understand if success is achieved. Ecological modernization can miss the mark on unpacking uneven geographies of development rooted in colonialism and capitalism and the resulting uneven distribution of environmental change impacts (Özkaynak, 2019).

Analysis by Robbins (2001) reveals how State modernization in Godwar, India altered smallholder farming livelihoods through agricultural intensification and by reducing access to traditionally used forests. State intervention sought to sustain crops at high yields, decrease diversity, and institute standardized forest enclosure policy (reminiscent of industrializing Europe). However, the State-led approach resulted in negative social and agroecological outcomes including decreased production, reduced access to natural resources, homogenization of farmer economies, and expansion of invasive species into a nearby forest ecosystem (Robbins, 2001). Local knowledges were skirted by the State, perhaps because they naturally resist imposed development from top-down institutions that limit diversification and agroecosystems (Bezner Kerr et al., 2022). Continued understanding of the effects of State interventions through environmental and climate change policies is needed in critical research (Robertson, 2020). Political ecology's interdisciplinarity helps to unravel complex power dynamics promoting discourse activism bent toward social and environmental justice (Wisner, 2020).

Social-environmental entanglements elucidate the complex geographies ever present in development including adaptation and resilience. Ecological modernization through State or private development is further challenged by increasingly unpredictable seasonal and long-term climate variability. Moreover, farming is multifaceted with connections and uneven geographies between social, political, institutional, and environmental sectors that can be beneficial or harmful to global environmental systems and vulnerable people (Holt- Giménez & Shattuck, 2009). In South Africa, climate-oriented projects introducing well-pumping (Tang, 2022) and modern irrigation for rural farming communities have been studied, yet limited access to technologies and training for maintenance have hampered success (Ziervogel et al., 2006). Lasage's et al. (2015) research on successful dams in semi-arid Ethiopia demonstrate productive results from water storage using small-scale sand dams, which are relatively inexpensive, naturally filter water, hinder evaporation, and regulate mosquito breeding grounds due to subsurface storage.

Nearer to my field site, Dinko & Nyantakyi-Frimpong (2022) emphasize the complex negotiations for water resources and access based on legal pluralism in Ghana with tensions between customary (traditional) and statutory law based on British colonial intervention. It is not difficult to imagine the modern tensions that would arise from State development unsympathetic to customary laws and traditions. And like other natural resources of value, self-interested actors or institutions and marginalization of disadvantaged people is to be expected. While development projects both new and old can have good intentions, the top-down or *one-size-fits-all* approach often ignores cultural sensitivity and collaboration with local community members. Top-down projects are planned by distant experts or technocrats at higher echelons of governance or donor agencies, without extensive knowledge of local beneficiaries nor the nuances associated with their concerns (Kaiser, 2020). Poor rollout and management can lead to marginalization and other unintended social and ecological consequences causing further issues in the future.

In what is now the Upper East Region (UER) of Ghana, United States Agency for International Development (USAID) built 164 small-scale agricultural dams between 1958 and 1964 to provide farmer access to water in the dry season (Hunter, 2003). While the project was relatively successful in improving commercial agriculture and (at least temporarily) economic conditions of dam users, negative social-ecological consequences caused by dams increased standing water and fostered widespread ecosystem breeding grounds for endemic parasitic diseases including malaria (Plasmodium spp.), Lymphatic filariasis (Filariodidea), guinea-worm disease (dracunculiasis), and schistosomiasis (Schistosoma) even 40 years later (Hunter, 2003). Hunter (2003) also notes that the compounded effects of dam disinvestment and disrepair and thus lost economic potential further burdened communities with the cost of illnesses and no economic means for which to pay for treatment.

Bottom-up development underscores the need for local participation and agency to develop based on community needs, values, and other complex indices of success (Kaiser, 2020). Some contend

that this leads to inefficiencies and excessively uncoordinated decision-making across scale (Crescenzi & Rodríguez-Pose, 2011; Fraser et al., 2006). Alternatively, local insight and participation "ensure community ownership, commitment, and accountability to the development project as it seeks development from below" providing opportunities for communities to help themselves rather than allowing undermining by politically motivated actors (Kaiser, 2020: p. 94). Still, local scale bottom-up approaches are subject to State regulation and the globalized reach of capitalism that may impede local decision-making or access to resources and expertise in the first place.

Homogenizing unique communities risks unnatural uniformity and cultural disintegration (Kaiser, 2020; Scott 1998), particularly when the State views society in terms of the dichotomous fractures of traditional and modern dualities (Hausermann, 2018). The distance between State decisionmakers and local communities problematizes development programs through their very own inefficient and dissociative nature (Kaiser, 2020). As such, self-organized climate change adaptation from the bottom-up can find itself in contest with other self-organizing institutions, specifically the State and globalized markets in which it is subject to. In this way, some social groups and their environments may be impacted by climate change and globalization in what O'Brien and Leichenko (2000) call a *double exposure* regardless of whether bottom-up or top-down approaches to development are used.

2.2 Climate Change, Development, and Agroecology

In sub-Saharan Africa more broadly, as temperatures rise and rainfall becomes more erratic, smallholder farmers are expected to be vulnerable to climate change events (Baffour-Ata et al., 2021; Tirivangasi, 2018) including flooding and droughts (Jarawura, 2021; Mohammed et al., 2021). In arid regions, these sudden or slow onset natural hazards can have effects on agriculture (Marks et al., 2009), water (Ersado, 2005), health, and socioeconomic security (Jarawura, 2021). Smallholder farmers, including those in northern Ghana, have long been adept at diversifying livelihood strategies to persist

through difficult periods including those related to climate change (Morton, 2007). Strategies include migration (Hunter et al., 2015; Jarawura, 2021; Piguet, 2013), use of traditional knowledge and innovation (Antwi-Agyei et al., 2018; Baffour-Ata et al., 2021; Nyantakyi-Frimpong, 2020; Omari et al., 2018), and utilization of non-governmental organization (NGO) and State interventions (Quinn & Akyol, 2021).

Climate change contexts call for renewed focus on State development strategies that support social-ecological systems in developing nations such as Ghana. Focus on climate mitigation, adaptation, and reduced greenhouse gas emissions dominated initial agendas of climate change discourses in the early 1990s – this led to a delayed response by development agencies to respond to climate change in less developed places for at least a decade (Ayers & Dodman, 2010). In more recent years, the link between development and climate change has become coupled with strong focuses on climate resilience, and adaptation (Antwi-Agyei et al., 2018; Kumasi et al., 2019; Mohammed et al., 2021). Resilience, in social science, was adopted from ecological rhetoric describing the ability and magnitude of an ecosystem to withstand disturbance before shifting to a different state where controls on function and structure are governed by the new conditions with influences from both above and below ecosystem scale (Folke et al., 2004). It is easy to shift this concept to be a more socially-oriented term, but perhaps even more importantly, as global systems change progresses, Folke et al. (2010) notes that there is a dire need for increasing acceptance that social and ecological systems are inextricably linked.

One of the greater challenges of climate change research has been the collection of data and creation of metrics that can accurately assess adaptation, and more specifically, adaptive capacity (Watts, 2020) including in social-ecological research (Ostrom, 2009). Like resilience, adaptation concepts, were borrowed from biology to explain behavioral or developmental responses to environmental stressors (Mohammed et al., 2021). The goal of adaptation should therefore be to simultaneously improve (or at least manage) resilience and decrease vulnerability to climate change

effects on social and biophysical systems. In society then, development is the spatially situated social manifestation of intentional adaptation, be it imposed from above, organized from below, or some combination of the two. The embeddedness of social-ecology in studies on adaptation identifies the profound connections between people's lived experiences, the spaces they occupy, and how they respond to convergences in social and environmental changes.

One contemporary example of how climate change resilience development is being implemented, is in the Green Wall megaproject funded by the European and African Unions, and the World Bank. The transnational intervention is meant to restore degraded land and stymie desertification across the Sahelian region, spanning from the Atlantic to the Red Sea and across numerous countries and political prerogatives (Andersson & Olsson, 2011; Mirzabaev et al., 2021). The wall is also expected to improve social well-being by providing labor opportunities, increase soil and agricultural fertility and thus food security, promote climate change resilience, add a carbon sink at scale (United Nations Convention to Combat Desertification, n.d.), and even curb terrorism and religious extremism (Schleeter, 2022). The project is deserving of heavy research efforts and scrutiny for generations to come given the colossal scale and social-ecological implications. The view from above only senses advantages improving social and ecological systems, including those at global scale. From the ground, land grabbing for an afforestation project and geopolitical meddling creates a social-ecological experiment across a vast biome with unpredictable outcomes for future generations.

To be most successful, some argue that climate change interventions should be collaborative and well-planned combining local needs and experiences with State planning and development (Smucker et al., 2015). A central focus of ongoing research and State development is to adapt to current and projected climate conditions, and recover from sudden and slow onset changes (Mohammed et al., 2021). In the drought- and famine-prone regions such as in Tigray, Ethiopia, State-developed micro-dams have been constructed to improve water access to rural farmers which has led to water

conservation and more irrigation, marginally better economies, and adoption of novel technologies (Ersado, 2005). However, as noted before, water capture outcomes from top-down development also led to unintended health consequences such as malaria and schistosomiasis in Ethiopia (Ersado, 2005), and other waterborne diseases in Ghana's UER (Abanyie et al., 2020; Hunter, 2003). There is thus a holistic component of maintaining local agency through bottom-up planning, and enabling of sustainable management for smallholder farmers else livelihood and farming resilience may be eroded by global effects of both State intervention and environmental change.

Put in context, rural smallholder farming continues to be highly susceptible to the effects of climate change due to high reliance on rainfed agriculture, exposure to natural hazards, market shocks, and limited resources to adapt (Ersado, 2005; Morton, 2007). Semi-arid agricultural regions are also over stressed from land degradation and aridification presenting challenging water issues in future years (Rosenzweig et al., 2018). Agroecology advocates contend that rural smallholders have long-implemented methods and experimentation that vary across space and time, and are well-suited to adaptation in specific social-ecological contexts (Altieri et al., 2012; Antwi-Agyei et al., 2014; Hausermann, 2014; Nyantakyi-Frimpong, 2020; Scott, 1998).

Additionally, smallholders tend to integrate or manage local landscapes to diversify livelihoods, improve production, and utilize natural resources (Morton, 2007). Agroecology focuses on interacting environmental indicators to manage and cultivate agricultural systems (Antwi-Agyei et al., 2014). It is widely used by smallholder farmers in many parts of the world (Altieri et al., 2012) including Ghana's UER (Baffour-Ata et al., 2021). Agroecology blends traditional and scientific knowledge of ecosystems with agrarian practices for improved and sustainable crop yields (Antwi-Agyei et al., 2014). It thus offers a valuable strategy for improving diversity and resilience of agroecosystems, and has emerged as a robust agricultural pathway toward mitigating and adapting to changing climates (Altieri et al., 2012; Wezel et al., 2009).

Given the complexities in resource management and development, there is a strong need for sustained research to determine the effectivity of agroecology in the context of climate change and development in the northern regions of Ghana (Baffour-Ata et al., 2021). Traditional agroecological practices are well-documented using meteorological and astronomical indicators, plant and animal observations, and soil management to improve basic ecological functions, water retention, nutrient cycling, and soil health (Baffour-Ata et al., 2021; Nyantakyi-Frimpong, 2020). Despite limited access to scientific methods, instruments, and climate data, smallholder farmers in northern Ghana have a deep understanding of soil health indicators, what drives productivity, and how local climates have changed over time (Amadou et al., 2015; Omari et al., 2018). Still, in many places around the world including Ghana, State interventions have been instrumental in modifying both private (Nyantakyi-Frimpong, 2020) and State resource management (Perreault, 2012; Sumani, 2019), and development (Hausermann, 2012) for smallholder farmers.

In Ghana specifically, there is recent research identifying a shift away from traditional agroecological methods by younger generations such as greater mechanization and agrochemical use (Antwi-Agyei et al., 2018), including in the UER (Abanyie et al., 2020; Baffour-Ata et al., 2021). However, access to modernized methods is not always equal among smallholder farmers in the northern regions and requires important training to effectively use new technologies, while preventing contamination and unintended ecological consequences (Abanyie et al., 2020; Demi & Sicchia, 2021). Agroecological practices may eschew the need for agrochemicals in modern climate change contexts, or traditional and modern farming may be creatively combined to improve yields. For example, many farmers are choosing risk-aversion strategies that simply mean new and faster maturing crops to reduce yield loss (Meze-Hausken, 2004). Further, water conservation and infrastructure including local dams, plus off-farm adaptation strategies can provide improved diversification to farmer livelihoods (Antwi-Agyei et al., 2014; Baffour-Ata et al., 2021; Nyantakyi-Frimpong, 2020; Van der Geest, 2011).

2.3 Smallholder Farmers and Climate Data

Agroecological foundations provide usage of a variety of techniques and technology to achieve sustainable yields in changing conditions. Even still, not only can access to climate data be an issue for smallholder farmers, but its usefulness and application needs to be catered toward local decisionmakers (Mosso et al., 2022). A burgeoning area of research is in the comparison of farmer perceptions of climate change versus long-term weather station data. There is a clear knowledge gap between the effects of climate change on smallholder farmers, and farmers' knowledge of their changing climate (Ayanlade et al., 2017). By better understanding farmer perceptions of climate change, their demographics and cultural priorities, and ensuing adaptive behaviors, policy and intervention can be catered more directly to communities to address their specific needs (Amadou et al., 2015). Communication between scientists and farmers can also facilitate collaborative solutions to their real-world challenges.

Farmers are clearly subject to more than just weather which can in turn alter their perception of climate change. Meze-Hausken (2004: p. 27) writes that "weather cycles tend to be idealized and simplistic, giving people the feeling of predictability and reliability … any deviation from this expected outcome creates insecurity." While perception of drought can be, for example, oriented in agro-social and economic factors rather than strictly environmental conditions, this differs entirely from a meteorological definition which is purely statistical (Meze-Hausken, 2004). Further, perceptions of climate change or anomalies are perceived differently depending on adaptive capacity, socioeconomic status, culture, politics, spatiality, and even timing. For instance, a dry spell of 30 days at the start of the growing season may lead to early crop failure, food insecurity, and economic burden if not remedied; these are some effects caused by a *statistical drought* despite the former example being a short-term anomalous event (Amadou et al., 2015). Similarly, other social or environmental factors may facilitate drought-like conditions in spite of normal climatological measurements (Meze-Hausken, 2004). These

complex social-ecological interactions are regularly dealt with by farmers, and in cases where extreme or unusual events occur, meteorological or otherwise, perceptions on climate change can be skewed (Meze-Hausken, 2004).

2.4 Study Area

Ghana's UER comprises of the warm semi-arid grasslands in the Guinea Savanna and Sudano Savanna ecoregions. Previous studies report unimodal convective precipitation patterns typically occurring between May and September annually ranging from approximately 600 mm to 1100 mm (Jarawura, 2021; Kumasi et al., 2019). The remainder of the year is dry and in water deficit with the warmest period being in the month of March (Kumasi et al., 2019). Recent meteorological data and

Figure 1. Nabdam district in the Upper East Region in Ghana.

farmer interviews in northern regions substantiate warming trends, increased precipitation variability, and a rise in the frequency of droughts and floods (Baffour-Ata et al., 2021; Jarawura, 2021; Kumasi et al., 2019). Climate projections suggest continued increases in temperature by at least 2°C and a decrease in precipitation by 2050 (Antwi-Agyei et al., 2018; Mohammed et al., 2021; Niang et al., 2014). Despite these increasingly challenging conditions, the area remains a key source of agriculture and food staples to the rest of the nation.

My field site is in the Nabdam district in the hinterlands and east of the municipality of Bolgatanga in the UER of Ghana at approximately 10°48'N, 0°48'W. I use *Savannah* as a pseudonym for the entire community, which is integrated into the rocky savanna grassland ecosystem with ephemeral streams and adjacent riparian zones, and occasional hilly terrain. Slightly higher population density and more retail establishments persist along the Bolgatanga-Zebilla Road, the primary highway nearest Savannah. The community lives in generally dispersed compound households, and is primarily agrarian

Figure 2. Satellite image of field site and approximate community boundary. Dam is noted with an arrow.

based. The dam of interest for this thesis has an approximately 0.9 ha catchment behind a 260 m earthen impoundment. Satellite imagery corroborates with interview participant responses that the dam was built in the dry season of 2019, likely in March, as part of the 1V1D initiative. The dam is located in a naturally low-lying east-west valley in an ephemeral stream that also flows from east to west. Above the reservoir are grassy community-shared grazing lands for livestock. Below the dam impoundment is a low-lying area where water collects and is regularly used for rice cultivation or livestock grazing. Upland and to the south, remnants of galamsey pits from past gold mining activities dominate parts of the landscape. Although local gold mining is not new to the area, the spatial extent of both new and old pits is nonetheless surprising. The dam's spillway is directly adjacent to these pits posing issues for the dam's functionality. Also, 80 m below the impoundment is what is called an "*Ancient Well*" long used by this and nearby communities. Participants describe the well as having water year-round, even if just a few meters below the surface in the dry season. In sum, the surrounding

Figure 3. Overview of Guinea Savanna landscape and Savannah community. Dam is noted with an arrow.

landscape is predominantly a mix of cropland, grazing lands, mining pits, streambeds, dispersed trees, and compounds.

Vegetation at the field site is dominated by trees including baobab (*Adansonia digitata)*, locust bean (*Parkia biglobosa*), acacias (*Accacia spp.*), and sheanut *(Butyrospermum parkii*) (Amadou et al., 2015). Mixed farmland is mainly used for various types of cereals, groundnuts, and rice with interspersed grazing lands for goats, sheep, cattle, and other small poultry such as guinea fowl and chickens. Specific crops include maize, numerous types of millet and beans, rice, and sorghum. With the exception of rice, most farmers row-crop and interannually rotate, using a mixture of locally produced manure and if affordable, commercial agrochemicals including fertilizers, herbicides, and occasionally pesticides. Maize and groundnuts are often planted together in polyculture, as are different millet types that mature at different times.

Figure 4. One of Savannah's manual pump boreholes with trough for livestock drinking.

Participants utilize various water sources throughout the year. Interspersed in the community are at least four hand-pumped mechanical boreholes with troughs for drinking, two brick-laid wells, and

what community members call an *Ancient Well.* These are all used for livestock and household needs. None of these water sources reportedly run dry. However, I expect that human and animal competition for water around boreholes and the *Ancient Well* increases during the driest months given the limited space to access their respective pools.

Other major water sources include five other dams near Savannah though at some distance and with unclear access to community members. Nearby dams range from 1.50 km to 3.50 km from the 1V1D site of interest and vary in size. Two of the five alternate dam sites were visited while in the field. The smallest of them was also part of the 1V1D initiative and had failed in the first season. All other dams were built prior to the 1V1D initiative.

Figure 5. Ancient well in August 2022. The dam's embankment is noted with an arrow.

2.5 Research Design

Placed in the contexts of climate change, in this thesis, I make use of political ecology's diverse rhetoric and framing to unpack the overlapping contradictions between smallholder farmers and agrarian development by the State, unexpected social-ecological responses to modernizing intervention and extraction, nature-society relations, and localized perceptions of a changing climate. Political ecology melds together historical context with critical social theory and post-positivist approaches to construct understandings of social and environmental processes based in theory, mixed methodologies, and strong political commitments to social-ecological justice and structural change (Perreault et al., 2020). Through this commitment to ethical dilemmas and uneven power, I acknowledge that relations also exist between researchers, subjects, and the spaces we study. The way in which we conduct our research affects our results, but so too can our research affect us as observers which should warrant self-reflection of our situated knowledge.

To collect data, I used a mixed methods approach unpacking development theory and comparing similar development empirics, conducting interviews, and evaluating smallholder perceptions and meteorological data. I chose my field site using high-resolution satellite imagery and visual change-over time analysis to find newly constructed dams within the time period of the 1V1D project. The status as a 1V1D site was then confirmed by one of my Ghanaian research assistants. Feasibility of access was also a consideration and prospective dam sites were narrowed down to a reasonable distance to a nearby minor city where my research assistants and I could travel from.

In the field, we conducted a maximum of four interviews per day to minimize issues of recall for our end of day transcription meetings. We also had days where it was difficult to locate participants (such as State officials), difficult to hire transportation, and we had a limited amount of daylight without mosquitos or other safety concerns. Due to risks from local conflict, our team returned to our guesthouse before nightfall. At the end of each day, our research team would collaborate to make

whole any missing components from handwritten notes, converting them into what I call *non-verbatim transcripts*. This process provided an opportunity for open discussion to alleviate any errors or mistranslations from multiple perspectives and helped advance the precision of interview data.

While generalizability is an issue in such a small study, budget and logistical challenges limited my research to a single demographic within a single community. With more time and funding, I would have broadened the scope studying multiple 1V1D communities, using alternative sampling techniques with more spatially distributed participants, performing more complex statistical analyses, and incorporating geospatial methods and analysis.

3 METHODS

3.1 Disclosure of Positionality

One of the key tenets of science is the practice of objectivity in conducting scientific research so that results are minimally or absent of researcher bias and subjectivities. Importantly, science has offered a presumedly objective lens through which subjective humans view and study the world. Science, along with other disciplines, exists through age-old layering of knowledge production which has roots through power relations between observers and subjects of interest. Modern science, a product of Eurocentric design, is produced by those with the means and access to do so. It limits alternative voices and manipulates knowledge production by its very nature leaning on unchecked biases such as through standardization and censorship (England, 1994; Haraway, 1988; Scott, 1998).

Attention must thus be paid to the complex subjectivities and intersections underpinning and perpetuating methodologies (Hausermann & Adomako, 2021). Reflections on positionality are meant to be challenging so as to engage with broader interdisciplinary knowledge and discourses, and not just (re)create exclusivity based on our own subjectivities (Hausermann & Adomako, 2021). I do not suggest that science itself is moral or immoral, or has not benefited humanity or provided deeply fascinating and groundbreaking discoveries about the universe in which we exist. However, acknowledging the ways in which our knowledge is situated may help to build meaning that is less reductionist and more collaborative drawing closer the extremities of power resulting in better outcomes and results (see Haraway, 1988). Self-reflection discourses can help uncover and mitigate our prejudices in scientific writing.

I exercise these practices by acknowledging my own situated knowledge and privilege that I bring to my research, and that developed through the process of working on my thesis. Researchers

engage in their investigations with preconceived understandings of the subject matter and normative behaviors. I bring my own partiality to this thesis project as a white, male, heteronormative, western-educated, American citizen which allows me the power to construct and carry out such a research project. I strive to report accurate representations of participant perspectives though rigorous methodologies and reflexivity, though I am still bound by academic and life experiences and knowledge which governs what I can produce. Qualitative research tends to generate a narrative which shapes the nature and outcomes of a project, itself, not so independent of the researcher (Boulton & Hammersley, 1996). Balancing the principles of data collection, adhering to scientific consistency, and yet daily exposure to the overt struggles my subjects face was never an easy task. I regularly questioned the intrinsic value and broader implications of my work given academic motivations and expenses incurred versus the socioeconomic hardships and food insecurity I witnessed.

As a person in my position, I had the privilege to travel to the far north of Ghana over 20,000 km away from my home in Colorado. For the duration of my stay near my field site, I had safe and comfortable accommodations, access to safe and affordable food and water, and (mostly) reliable transport. Access to most of these creature comforts is an exercise of power and privilege which I acknowledge was not available to my human subjects. Despite my complete foreignness to the community, I was granted virtually unencumbered access to deep insight into the lives of each and every participant. My access was clearly the result of my positionality which allowed me to travel halfway around the world to interview *them*.

As part of the fieldwork, I paid two Ghanaian research assistants, Hegelar and Awudu, to help conduct interviews, translate, transcribe, and navigate social norms. Both were male, in their mid-30s, multilingual, college-educated in Ghana, and had previous interview experience. Hegelar was coincidentally born in Savannah which *could* have clear implications for impartial research and this issue was addressed prior to fieldwork. However, studying one's own community can also provide *insider*

status, which gains the researcher access and data unavailable to outsiders (Lipson, 1991). Although we came upon a few participants known to Hegelar, he maintained a professional demeanor sticking to our interview guides and allowing *their* voices to be heard. Throughout, we respectfully collected data from sources relying on real interactions and dialogues with participants, which give human voices and narrative to the topics of my research. Fieldwork should "minimize appropriation by avoiding misrepresentation and extending the idea of a reciprocal research alliance between the researcher and the researched" (England, 1994: p. 86). Prior to interviews, I reminded both research assistants the importance of translating participant responses as closely as possible to accurately capture *their* perspectives, and not our own. Having multiple interviewers present helped to interpret participant responses minimizing misrepresentation.

Still, as three male researchers, we could not fully account for the patriarchal norms that exist in Ghana and at our field site. We strategically attempted to interview women separately from men to decrease their discomfort in knowledge sharing in relation to other community members, but there is no way to know if (or more likely *how*) their responses would be different if interviewers were female and/or Ghanaian. As part of our normal protocols, we assured all participants of confidentiality and yet I still acknowledge that interviews are inherently disruptive or an intrusion of participants' lives; after an interview, subjects are not free to leave in the same way that I as a researcher am (England, 1994).

In at least two interviews, women noticeably diverted to male perspectives when men entered the scene. In another instance, both female participants left the interview entirely after their husband interrupted our interview to share his own thoughts. Despite our best efforts, more men were interviewed. Still, in a few family interviews, men and women shared (seemingly) unique perspectives which provided gendered insight. Despite male dominance, I acknowledge that the presence of both research assistants bridged the gap between participants and a western researcher that would have been otherwise difficult to cross and I was appreciative of their professionalism, attention to unequal

gender norms, and commitment to scientific rigor. As a team, we were collaborative, thorough, and served as mutual checks to facilitate quality data collection.

More than half of participants wanted to know how my research would benefit them and the community. Again, this strikes at the heart of positionality where many participants expressed curiosity at not just my presence, but my purpose. This is a question I anticipated, and answered with sincerity which fell on hopeful ears. All interviews were conducted voluntarily perhaps with the understanding that my privileges and access may provide benefits to them directly or indirectly. Knowing this, my team and I explicitly made no promises or illusions of what would come from my research. We were there to collect, compile, and interpret data, and report results. Perhaps, documenting a collective voice to compile in a separate report was enough for my participants to participate. I have since written this report and Hegelar is in discussion with community leaders on how best to present it to the community at large in the coming months. We are prioritizing full access to all community members including paper and digital copies, and verbal translations to those who are illiterate. However, I do not expect it to be viewed by the higher echelons of the State and if my findings are inaccurate or misrepresentative according to the community, I am obliged to correct them. Balancing the limits of my research, desire to improve community circumstances, and own selfish desire to complete my thesis seeded ethical dilemmas not uncommon in social science. Further, I do not wish to emulate State failures and underwhelming promises described in the very interviews I was conducting. In any case, I am grateful to each participant for diverting their attention from their livelihood to share their experiences.

3.2 Qualitative Interviews: Sampling and Analysis

In early 2022, institutional review board (IRB) approval was granted for field work in Savannah. Prior to arriving in the field, my research assistant, Hegelar, contacted the local assemblyman for Savannah to gain permission to conduct my research project. It is standard practice across rural

communities in Ghana to gain entry by community leaders or chiefs. In June 2022, we conducted 29 semi-structured interviews with community members, local leaders, and State officials associated with Savannah. Upon arrival, we met with Savannah's local assemblyman in the nearby municipality of Bolgatanga to discuss the project further and formalize our presence. The following day, we began our interviews.

Semi-structured interviews are widely useful for probing perspective responses from people regarding their thoughts and experiences about a particular topic of interest or phenomena (McIntosh & Morse, 2015). They utilize a detailed interview guide to direct an interview based on previous knowledge or research of the object of analysis and responses can provide rich descriptive data for analysis (Boulton & Hammersley, 1997; Halcomb & Davidson, 2006). For my fieldwork, I produced two interview guides: one for community members and another for State officials. Once in the field, interview guides were slightly modified based on relevance and with input from both research assistants (see Appendix for both interview guides[1]).

We interviewed 27 community members. Often in rural Ghana the presence of a white researcher draws interest from others who gather around during an interview and chime in occasionally. Several interviews thus turned into us talking to two or more adults who were typically family members. Overlap or differing perspectives between individuals were documented and included in analysis. Interviews were conducted verbally by the research assistants and I, most often translated into the local language (Frafra). Interviews lasted between 30-60 minutes and were audio recorded with explicit permissions from all participating parties as per Colorado State University IRB requirements. Detailed

[1] Interview guides have been updated to reflect changes made in the field.

hand-written notes were taken during interviews as the research assistants translated responses into English.

Two interviews with State officials were conducted in English. These interviews were chosen based on involvements in Savannah, knowledge of the dam site, and their availability. All State officials were unaware of my research prior to our interviews which produced unplanned responses. State officials interviewed included the Nabdam district agricultural officer and chief engineer at the Ministry of Food and Agriculture (MoFA) in one interview, and the Nabdam District Chief Executive (DCE) in another. We also interviewed Savannah's unit committee member, who is a community member and leader, but not a State official. Additionally, we conducted an interview with a district health coordinator living in Savannah focusing specifically on health topics and the dam.

Although I understood from a community leader there were approximately 500 residents in Savannah, including children, I was unable to determine the community's physical boundaries from the beginning, specifically to the northeast where compound homes were more dispersed. I can only estimate rough community boundaries based on an older participant's account, but they are not exact (see Figure 2). With the information that I do have, I estimate that there are 170 households in Savannah and that our sample size accounts for approximately 16.5% of the community. My goal was to interview men and women separately and with equal n-values. In Ghana, gendered divisions of labor and household duties are rooted in uneven socio-structural systems (Ferring & Hausermann, 2019). Women's perspectives, I hoped, might elucidate experiences that challenge normative rhetoric. Still, cultural practices made our goal challenging to recruit women alone.[2]

[2] To account for multiple voices in group interviews, we gave all participants equal opportunity to voice their perspectives. Group interviews proved quite productive because there were regularly a few standout voices in each group, including both men and women, and it was clear where people disagreed.

In terms of sampling, I focused interviews on a subsample of Savannah's community members nearest the dam making a reasonable assumption that participant proximity would make them more regular users than those further away. My inclusion criteria for participants were to (1) be farmers, (2) have knowledge of the dam site, and (3) have been residents of Savannah for a minimum of 8 years. The decision to narrow my population sample to participants closest to the dam is acceptable under typical purposive sampling guidelines and I acknowledge that this study is place-based and with contextualized generalizability (Robinson, 2014). Some of the disadvantages of non-probability sampling are researcher biases associated with inclusion/exclusion criteria and its poor external validity (Andrade, 2021; Etikan et al., 2016). In other words, with greater distance from the dam site, I would expect participant sentiments and perceptions of the dam to be at least somewhat varied from those nearest to the dam. If the community's boundary had been known, I expect that random or spatially stratified sampling would have provided better approaches for understanding farmer behaviors and perceptions of the dam in Savannah. However, one of the main strengths of purposive sampling is its ability to provide *rich* data from participants relevant to my study. In this case, I refer back to my research questions which have an inherently qualitative scope.

Furthermore, and despite its limitations, purposive sampling is an efficient method when there are constraints on data collection (Etikan et al., 2016); in our case these were limited time and resources, geographical limits such as distance between household compounds, varied terrain, high temperatures, and our general safety. To minimize impacts on farmer productivity and safety, interviews were conducted voluntarily during the heat of the day when farmers are willing to take breaks under the shade of trees. Conducting interviews during cooler mornings would have infringed on farming productivity, and in evenings, could risk mosquito-related infection.

Upon return from the field, research assistant Awudu and I transcribed 11 interviews verbatim. The advantage of transcribing interviews in which you participated are clear given the first-hand

knowledge of the participant and interview (Halcomb & Davidson, 2006). Due to limited time and budget, not all interviews could be transcribed verbatim, yet even non-verbatim transcripts were highly detailed for a thematic analysis. In the field, I made notes of which interviews would be best to transcribe based on length, quality, descriptiveness, unique or ubiquitous sentiment, and other factors. Because I also had non-verbatim transcriptions for every interview which were cooperatively produced by our research team, verbatim interviews added clarity, details, and nuanced language. The use of detailed notes and mixed methods for interviews can produce sufficient validity in data (Halcomb & David, 2006). "Thematic or content analysis seeks to identify common ideas from the data and, therefore, does not necessarily require verbatim transcripts" particularly since verbatim transcriptions are subject to human error, misinterpretation, or cultural differences which can further muddy the analysis (Halcomb & David, 2006: p. 40).

Per grounded theory methodologies and to improve the data analysis, an inductive scaffolding of evidence from interviews was built in increasingly higher-level codes and themes, eventually forming the basis for clear and empirical claims (Boulton & Hammersley, 1996). I performed a close reading of all interview data noting similarities and differences, patterns, and reoccurring words, phrases, sentences, *insider terms*, sentiment, or other themes to be added to my codebook. Using the codebook, I performed an iterative thematic analysis of both non-verbatim and verbatim transcripts to extract valuable data recording it into a Microsoft Excel spreadsheet. From here, codes were chunked into themes and could then be sorted for frequency and descriptive statistical analysis (Leech & Onwuegbuzie, 2008) which was the foundation for a community narrative and my claims. Because just 29 interviews were performed, data processing was completed manually in order to humanize and become more familiar with the people behind the data. To preserve validity and reduce interpretive bias of the data, I regularly checked my field notes and reflexivity journal for my own sentiments, social

position, judgements, personal bias, perspective, and any other noteworthy interactions, experiences, and observations that might skew data.

3.3 Meteorological Data and Analysis

Quantitative meteorological data was collected from the Ghana Meteorological Agency headquarters in Accra (2022). The two nearest weather stations to my field site are in Bolgatanga and Zuarungu: 12 km and six km, respectively. The distance between the weather stations and my field site is consistent with other research to interpolate long-term climate conditions (Amadou et al., 2015; Ayanlade et al., 2017; Meze-Hausken, 2004). Data includes monthly precipitation from 1980-2020 for both stations. Minimum and maximum temperatures for Bolgatanga were available from 1980-2020, with minimum temperatures from Zuarungu only available from 1990-2017 and maximum temperatures from 1990-2020. For both temperature and precipitation, cells with missing data were replaced using the remainder of the dataset for each corresponding month to calculate a monthly mean. This is an acceptable method if valid monthly data are available for that month in at least 80% of the years in the dataset (World Meteorological Organization, 2017). After replacing missing cell data, the difference of individual monthly mean temperatures between the two weather stations using their total time-series was no greater than 0.5°C for minimum temperatures, and 0.9°C for maximum temperatures. Perhaps more importantly, annual mean differences were between 0.1°C for minimum temperatures and 0.4°C for maximum. The difference in annual mean precipitation between the two sites was only 8.4 mm, suggesting consistent climate patterns between the two stations and strong evidence of proper use of methodology.

Qualitative data of climate patterns was measured from interview responses. Participants were asked how the rainy and dry seasons had changed between their younger years and the current day. If answers were not specific enough, depending on their age, I further prompted them to reflect on when

rains started and ended for the growing season, both when they were younger for older adults, and when they were a child for younger adults. Because I am relying on memory which over time can become more *gist-oriented* (Gallo et al., 2019), some amount of variation in answers was expected. For example, participants answered that rains started in March, March or April, or April. Other participants responded that it 'varies', 'starts late', or 'ends early'. I created discrete categories based on these and similar participant responses. In other cases, participants did not know how rainfall had changed or did not respond to the questions and so were omitted from the measurements.

It should be noted that because sentiment about rainfall was an important topic of conversation often initiated by many participants, comparison of weather station data and farmer perceptions was a logical topic of research a posteriori. I did not further inquire regarding temperature changes over time in the field. This was an unfortunate oversight since temperature perceptions are more subtle to measure qualitatively over long periods of time, and would have been interesting data to analyze. This limits the scope of this aspect of my research to precipitation data comparisons only. However, temperature data collected can still be useful for measuring trends and is an important variable on changes to evaporative demand and how it may affect public perceptions of water availability.

4 RESULTS AND DISCUSSION

In the results and discussion section of my thesis, I discuss my key claims in relation to the implementation of the State-led dam project more broadly and at my field site, unexpected social-ecological impacts linked to the dam, and how climate change is perceived by farmers as compared to weather station data. My thesis claims are:

1. *The State failed at a community-based approach in the dam placement and development, and local preferences were largely marginalized for performative State intervention at the federal level.*
2. *There were unexpected social-ecological impacts linked to the placement and spatiality of the dam.*
3. *Galamsey prevalence and its destructive nature in Savannah remains a major threat to the social and ecological systems.*
4. *Climate change is experienced by participants differently than meteorological data represents.*

I have arranged the results and discussion section based on my key claims organized into corresponding subsections. I have come to these results through extensive hours of field work and literature review, data processing and analysis, ongoing correspondence with my research assistants, collaboration with my advisory committee and colleagues, and much self-reflection. Connecting participant experiences to real world phenomena, whether State imposed, climate change induced, academically debated, or otherwise novel, is key to improving the research body and circumstances of each affected human and their interactive place within their ecosystem. My overarching goal is to not perpetuate extractive processes for my own gain, but to consider the data coproduced by participants and researchers

equally. As such, my thesis reflects the real implications of large-scale and under-researched State development for which future research and interventions can improve upon.

4.1 Sidelining Community Input for Outside Experts and Conflicting Narratives of Success

According to the Nabdam DCE, prior to his election, President Nana Akufo-Addo visited the district speaking with chiefs and local leaders to better understand the needs of community members. In more widespread conversations, he assured local leaders that their primary concerns for water access would be addressed if he were elected. Then presidential candidate Akufo-Addo, in other words, toured northern districts performing as an attentive, charismatic future president who would deliver on local and regional needs and desires. The DCE recounted specifically that local leaders were concerned about dry season farming and gardening, and the distances livestock needed to travel for water. Given the history of underdevelopment and unimodal rainfall patterns of the northern regions with many months of water deficit, a large-scale water project would be expectedly well-received at the community level, regardless of political affiliation.

Table 1. Election results in the Upper East Region from previous three presidential elections. Bold indicates winner of general election.

	2012		2016		2020	
Candidate (Party)	Votes	Share (%)	Votes	Share (%)	Votes	Share (%)
Nana Akufo-Addo (NPP)	120,814	29.29%	**157,398**	**34.93%**	**175,400**	**34.44%**
John Dramani Mahama (NDC)	**274,019**	**66.43%**	271,296	60.32%	322,317	63.29%

1V1D initiative presents as a top-down attempt to mediate food insecurity and climate impacts, which have all too familiar (and local) failures based on shortsightedness and political motivation (Hunter, 2003; Scott, 1998). While local leaders seemed to be involved in specific aspects of the decision-making process, their advocacy was still subject to federal-level and politically-aligned technocratic scrutiny. For example, the local leaders' design ideas for the dam were ultimately ignored.

These types of small-scale dams are seen as viable interventions to address multiple development needs, including those associated with changing climate patterns and underlying political interests; uneven power dynamics have had serious negative implications on other development projects (Acheampong et al., 2014). And although he has not won majority in the UER in the last three elections (see Table 1[3]), President Nana Akufo-Addo may have earned favorability with his development initiatives, including the 1V1D.

As part of the implementation of the 1V1D initiative in the Nabdam district, the regional MoFA office presented a water needs assessment of all the towns, villages, and communities to a National Team (NT) of NPP appointed officials, technocrats, and engineers based in the capital Accra under the MSDI. Their assessment indicated locations for unmet water demand in the district. Using this assessment, the NT awarded 10 dams to the Nabdam district and together with the district assembly, dams were awarded to 10 communities. As part of the initiative, each community was allowed to propose three sites to the NT who would then conduct their own study and determine site suitability. The DCE, a woman, insisted that both men and women in Savannah were involved in the decision-making process yet no other participants indicated female involvement in the decision highlighting the gendered nature of the process. This is unsurprising given the unequal social status women have in Ghana (Ferring & Hausermann, 2019; Hausermann et al., 2018).

Community involvement in the process of dam development is historically minimal with State or donor institutions imposing specific development objectives without beneficiary knowledge or consultation (Acheampong et al., 2014; Hunter, 2003). The community leaders in Savannah proposed

[3] There is a discrepancy in the 2020 election with the Electoral Commission of Ghana (2023) reporting 170,340 votes (32.84%) for Akufo-Addo and 335,502 votes (64.68%) for Mahama. Remaining data collected from PeaceFmOnline.com (2020a,b,c).

the rehabilitation of two existing and nearby dams, or new construction at an alternate site. After reviewing their three site proposals, the NT decided on a new dam embankment site approximately 80 m upstream from where the community proposed the placement. One participant stated “we proposed a different place for them [the dams] but they refused and brought it to this current location. We were surprised.” The contract for construction was awarded by the State to a contractor based in Accra, which was then subcontracted to a regional company. Moreover, the State’s effort to have communities put forth ideas about dam sites, based on local social-ecological knowledge, to later ignore these locations for outside “experts” was frustrating to local community members.

The dam construction was completed in one week and without any serious community involvement in the decision-making or building process. Although the State encouraged the community to participate as a watchdog, and several complaints were logged locally, there is no evidence that the NT or contractor heard the complaints or responded. Further, the subcontractor carried no official permits nor documentation to make official their expertise and involvement in dam construction. This was especially noteworthy since the Nabdam district engineer was not allowed to be officially involved in the design or provide any oversight. Here we are reminded of the chasm between State and local decisionmakers in development projects (Kaiser, 2020) to the detriment of community members who have no recourse for poor design and construction of an imposed State node of control.

Complaints by community watchdogs included the insufficient height of the impoundment and spillway, poor structural reinforcement, and location of the dam. One participant summarized a common sentiment:

> We wanted it to be taken downwards [constructed downstream] further, make it wide[er] with [a] tall[er] embankment so it could hold more water for us. Now, two heavy rains can fill it up. This means it’s very small and shallow. The spillway is very low as well as the embankment so water runs out if it rains heavily. The dam wasn’t constructed to meet our expectations.

The low spillway limits the overall capacity of the dam well below the primary embankment. The lack of a lateral embankment allows for loose sediment, particularly galamsey deposition, to infill the dam and damage the spillway; this was also acknowledged by the Nabdam agricultural officer and district engineer at MoFA. They, and numerous other participants, noted the speed at which the project was completed left no time for modifications, community participation, nor for complaints to be addressed. MoFA and others also lamented that the subcontractor intended to complete the work and get paid as quickly as possible. While national and regional level officials may have had good intentions with community participation, in the actual construction and development of the dam, community insights were sidelined and the project was completed quickly with no time for processual reflection or dialogue. In many cases, community members reported that they knew early on in construction that the dam would be difficult to use.

In January of 2022, a subcontractor did return to lay stones on the embankment and reduce further damage, however, much infilling had already occurred. Many people, including the DCE, said they simply trusted the NT to design and construct a robust dam that would be most functional to capture sufficient water for dry season use. This understanding was based on State assurances to the community. Most participants expressed disappointment and resignation of the dam's underwhelming capacity[4].

To make matters worse, community members and local State officials (the DCE and MoFA) have no legal entitlement to the dam infrastructure as no official documentation has been provided. No customary handover (*durbar*) of the dam has been made to the community by federal officials, though

[4] Of note, we visited another nearby 1V1D site and a single group interview was conducted which mirrored the disappointment in Savannah. This neighboring dam was even smaller than that of Savannah, had an even shorter spillway, and was reportedly leaking water under its impoundment.

this was promised and is expected with customary practices in Ghana. When asked about expanding the dam, one participant explained:

> They said they will come and expand it but we have not seen them yet. Our government will tell us that they will come but it may either take too long or they will never come at all. I fear that if there is a change in government, the new one would not like to improve that of the previous government project. We wish it will be expanded one day so that our people will not migrate to the south.

As such, from day one, the community and local officials could not make any modifications or repairs to the dam and its surrounding structure which has quickly led to structural disrepair and further disfunction. It is still unclear as to who is responsible for repairs and management. In similar dam projects in northern Ghana, the responsibility has fallen on local communities (Acheampong et al., 2014; Hunter, 2003).

The disconnection between the State and community level draws more acutely on the issues of legal pluralism that persist in Ghana today (Dinko & Nyantakyi-Frimpong, 2022). Without official

Figure 6. Savannah's dam embankment and water in mid-June 2022.

handover ceremonies and State documentation provided to local officials, the dam's actual existence lies in a state-of-limbo where federal officials assume its politicized existence is a success, and community members resignedly make do with its underdeveloped utility, but no action can be taken to reduce its atrophy, nor are State authorities able to be held accountable. Should the community wish to improve the dam, such as to dig out sediment or add irrigation channels, official handover from the federal State is required prior to any such action. Again, in the case of 1V1D in Savannah, there appears to be a significant disconnect between what was initially a participatory approach to development, and incomplete and top-down implementation and infrastructure turnover.

State development projects can serve as outposts of intervention and control directly tied to performative action by minimizing local knowledge and desired modernization (Robbins, 2001). It is also important to not assume homogeneous development goals inter- nor intra-communally. For example,

Figure 7. Savannah's dam embankment and water level in mid-August 2022.

despite the natural deficits of water in the region and my field site, water politics are rooted in historical and sociopolitical unevenness that differentially impact communities and groups of people within communities (Dinko et al., 2019).

Furthermore, it is unclear exactly how many dams have been constructed yet the State expected all dams to be completed by the end of 2022 (Nartey, 2022). Agyeman and Bruce reported in February of 2021 that the Minister designate for Fisheries and Aquaculture Development stated that 426 dams had been fully completed under the MSDI. While this is indeed a huge number of dams, the quality of those dams and their ability to effectively retain water for dry season farming remain questionable, particularly given the results of this study. Furthermore, opacity regarding the specific number of completed dams and their locations raises questions of 1V1D politicization, transparency, and organizational efforts for such an ambitious hydro-social project in Ghana's northern regions.

In some ways 1V1D further perpetuates what Zaidi calls "the general caricature of the state as a result of its failure to deliver development" (1999: 261). It is this formulaic nature of State development that "relies on bureaucratic mechanisms and seeks enforced compliance with government decisions, made by experts according to technical principles and criteria following policy objectives set by top officials" (Uphoff, 1993: p. 610). Such interventions and approaches, moreover, are nothing new. Models of top-down authority, modernizing development, performative actions, and political manipulation discourage community involvement, collaboration, or bottom-up approaches (Zaidi, 1999). In Savannah, this model has generated new interactions between farmers, their land, and water resources, which have not addressed the root issues at hand.

Participants mostly disapproved of the dam and yet State discourses promote success of the 1V1D initiative at large without much in the way of any official documentation nor research (Apinga, 2020; Nartey, 2022; Parliament of Ghana, 2019). This is different from social media comments and news

reports that publicly criticize local 1V1D functionality and rollout, blaming the president and the NPP for its failures (GNA, 2022; Sore, 2020; Tarlue, 2019). Elsewhere in Ghana, dams are justified through nationalistic and pro-dam discourse marketing dams as modernizing, poverty alleviating, (Hausermann, 2018), sustainable, inexpensive and simple, and robust sources of renewable energy (Özkaynak, 2019).

Still, given the lack of peer-reviewed and transparent research and complexity of the initiative, the larger scale implications of 1V1D are not yet clear. Much of what is understood so far is reminiscent of a mid-20th-century USAID dam project in Ghana, where poor rollout, disinvestment and disrepair, and negative social-ecological effects (Hunter, 2003) all seem to be present. Preliminary reports from the UER indicate risks of bacteriological and chemical contamination at unsafe levels in some watersheds and dam sites (Abanyie et al., 2020) and inadequate water capture or failure in others (Smith, 2019). Indeed, the federal government may have fallen short on promises, despite the will to improve (Li, 2005), resulting in new human-environment interactions which include water quality issues and crocodiles.

4.2 Unexpected Social-Ecological Implications of the Dam

As with any social-ecological engineering project that alters levels of ecological function and social systems, researchers start by trying to understand the base level outcomes and implications of the intervention. At my field site, this begins with one simple question: *does the dam work as it was intended*? 1V1D dams are meant to relieve local hardships brought by low water access at a modest cost (Asamoah, 2019; Smith, 2019). Further, access to additional water during the dry season was expected to extend the growing seasons, enhance productivity of arable land and livestock, improve nutrition (Feed the Future, n.d.) and reduce the need for seasonal out-migration for economic means and livelihood improvement (Asamoah, 2019; Smith, 2019).

Comparing the initiative's objectives and the responses from interviews reveals the simple answer: the dam does not function as community members had been assured by the State. Overwhelmingly, participants do not use the dam for dry season gardening, and do not exclusively rely on it for their livestock particularly as the water level nears empty midway into the dry season. One participant explained:

> I would like to say that at least the animals have water for some time until it dries up. I cannot say it is completely useless if somebody has said so. The issue is it didn't meet our expectation. We don't use it for cropping or irrigation so I haven't seen any changes in our farming because of the dam.

While virtually everyone interviewed uses the dam for livestock during the rainy season, and most for constructing mud homes, there are no participants that use the dam water for crops at any time of the year. Ghanaian media also reflects an inability for 1V1D dams to be used for irrigation (Sore, 2020). More descriptive statistics are found in Table 2.

One interesting exception to this perspective came from the DCE who believed the dam was being used for dry season gardening and that it was of sufficient size for the community, though she acknowledges its shrinking size due to galamsey washout and infilling. The DCE is so confident of its success that she intends to develop commercial mango and cashew farming near the dam to improve dry season economies and decrease mining practices and out-migration of the youth. However, her perceptions were in direct opposition to community members' feedback that the dam is not used for farming, likely indicating that the DCE simply did not clearly understand post-dam dynamics in this community. Indeed, not a single community participant mentioned this local development project nor successful planting of commercial trees for income. The initiative's approach to simply mitigate localized effects of a global-scale climate shift through water resource access distorts the complexities and power-dynamics by which people adapt, including when they remain in place, migrate, or are vulnerable in the first place (Black et al., 2011; Carr, 2005).

4.2.1 Impacts on Migration

To offset the low water availability and poor economic opportunity in the community, more than half of participants expressed that seasonal migration had not changed since the dam was constructed, suggesting people still search for income outside the community when there is little water and no agricultural economy. Participants engage in wage labor in nearby cities like nearby Bolgatanga. Others migrate to larger cities including Kumasi, Tamale, and Accra which have more wage labor economic opportunities. City migrants regularly described having low wage positions, most notably as porters in bus terminals and other busy locations. As of now, low wage labor may still be more advantageous when farming in Savannah is not possible. This reflects other research on how subsistence farmers in rural areas, particularly in younger demographics, may be eager to escape agrarian livelihoods altogether (Li, 2009). Modernizing development is associated with urbanization and the promise of wage employment and prosperity (Li, 2013). Yet, in some places including Savannah, State intervention focuses on solutions to local hardships by providing some access to *mainstream modernity* (Li, 2013) in an attempt to control migration and maintain internal food systems. Participants practice subsistence farming where little to no excess food supply is common. Food insecurity was clear:

Table 2. Descriptive statistics for interview participants excluding State officials (n=27).

Variables		Number of Interviews (n)	Percentage (%)
Interview Type	Male	14	51.9
	Female	9	33.3
	Group	4	14.8
Food Insecure	Yes	20	74.1
	No	7	25.9
	No Response or Unsure	0	0.0
Dam Used For Animals	Yes	25	92.6
	No	1	3.7
	No Response or Unsure	1	3.7
Dam Used for Crops	Yes	0	0.0
	No	27	100.0
	No Response or Unsure	0	0.0
Dam Size Too Small	Yes	26	96.3
	No	0	0.0
	No Response or Unsure	1	3.7
Changes to Rainfall Patterns in Lifetime	Yes	23	85.2
	No	2	7.4
	No Response or Unsure	2	7.4
Changes to Migration Since Dam Construction	Yes	2	7.4
	No	16	59.3
	No Response or Unsure	9	33.3

> It's not enough for feeding the family through the year … we have to buy more food from the market to feed until the [end of the dry season] ends. I don't talk about selling my crops at all. It's a man's responsibility to feed his family. When there is food shortage, I look around and engage in any economic activity that will fetch me some money to buy[sic] food. If I don't get any, I will then sell some animals to buy[sic] food for the family.

Of those who chose to stay in Savannah, more than half of participants sell their livestock in order to supplement food shortages, and over two-thirds report food insecurity (Table 2). As such, participants rely on their food stores, livestock, purchasing food from nearby markets for food, and various other non-agrarian economic engagements or remittances from seasonal migrants for money. Because the water shortage is so great, dam capture is insufficient, and there is no dam irrigation infrastructure, there can be no effective dry season farming.

4.2.2 Issues Regarding Dam Water Access

Savannah's dam was supposed to address water access for farmers, and yet its capture continues to decline. The dam is reportedly dry by February or March, two-to-four months prior to the start of consistent rains depending on the year and participant responses (see Figure 13 for monthly trends). While some participants translate *dryness* as absolute, meaning no water remaining, others interpreted the dam's empty state as when the water is no longer accessible. As the dam dries up, the remaining water becomes increasingly muddy which is a hazard for livestock and humans, not only for contamination and health reasons, but because access can be dangerous with higher risks of drowning or getting stuck in the thick mud. In one sense, there may still be water in the catchment, but getting to it is not an option for everyone.

The catchment area also has safety concerns. In one interview where various participants chimed in, everyone agreed swimming in water captured by the dam was prohibited due to safety issues regarding drowning, getting stuck in the mud, and because at least one crocodile had been observed in

the water. The crocodile sighting was confirmed in numerous subsequent interviews, and based on its novelty to the community, I regard it as an ecological surprise from the development project. Participants at another 1V1D dam nearby also noted a crocodile sighting in their own dam, which was equally novel to them. Several participants in Savannah mentioned livestock had been attacked by a crocodile. The introduction of crocodiles following dam construction was a concern for community members.

Water centralization on the landscape can also have unexpected impacts. Damage from galamsey is diminishing the capacity of the dam with negative consequences for non-miners, including all interview participants, and is explored further in section 6.3. In another example, participants across a busy highway expressed complications with dam access as road crossings with larger livestock was a serious risk. One group interview revealed that the family had lost all but one goat that season due to traffic related deaths. The dam and some of the grazing lands they use are located on the opposite side of the highway from their home. So, while the dam centralizes water for community members south of the highway protecting their larger livestock from wandering into the highway, those to the north face increased risks for their livestock each time they cross for a drink of water.

Several participants on the dam-side of the highway diversify water access by using Savannah's dam and a nearby dam to the northeast. In most cases, farmers drive larger animals to the dams and boreholes, or manually carry smaller amounts of water back to their compounds for smaller animals and household needs. In a few instances, participants described using motorized flatbed trikes (Motor Kings) to haul large barrels of water from the dam, but this seemed uncommon and I never witnessed these specifically at my field site. One participant also described purchasing water at the nearest gas station and hauling it home on his Motor King. These examples demonstrate both the challenges and creativity of participants to access nearby water sources, as well as the limitations of the 1V1D dam.

4.2.3 The Dam and Farming

This research found farming practices were minimally altered by the dam. Farmer expectations were that the dam would provide year-round water access for crops, gardening, and livestock, but no one expressed such definitive sentiments. Additionally, almost no changes to farm sizes were recorded in interviews. Only one participant acknowledged a change in farm size, which was directly due to the placement of the dam on his farmland. However, according to this participant and others, those that lost their land due to the dam's placement, did so voluntarily for the greater good of the community. Other community members then donated some of their farmland for them to construct new homes and plant crops.

These are examples of social-ecological adaptation and short-term losses for long-term gains in the face of altered conditions, including those meant to develop the community (Ostrom, 2009). Since most of the land lost from the dam itself was owned by two or more farmers, I expect very little grazing land was lost as a consequence of its footprint. And because the water collected by the dam is not used for crops or trees, I expect a net loss of net primary productivity overall. However, it is unclear whether community members are able to rear more animals, at least during the rainy season, because of higher albeit decreasing water availability due to the extensive loss of productive and communal grazing land from galamsey. These aspects of the community's land-use should be studied together in further research and gets at the limitations of scope in this thesis. With more time and funding, a probabilistic sample of the entire community certainly would have driven better statistical results and been more fully representative of community members further from the dam site and the potentially unique issues and concerns that they face.

4.3 Galamsey is a Threat to the Dam

Savannah has a long history of mining and was a prominent topic of discussion by participants. Galamsey was also cited as one of the biggest concerns for community members in relation to the dam. Similar to other areas of Ghana, galamsey – particularly when driven by foreigners with capital and machinery – can be extensively destructive to the natural spaces and impede on and alter the livelihoods of local communities (Ferring & Hausermann, 2019; Nyantakyi-Frimpong & Bezner Kerr, 2017). The area around Savannah is no exception. According to participants that discussed galamsey and my observations, the mining is mostly done by hand and almost exclusively by persons from outside the community. Although mercury or other chemicals were not observed for mining at these pit sites like in other areas of Ghana (see Ferring & Hausermann, 2019), other prominent disturbances and hazards are clear. The digging can extend down over two meters into the soil layer where gold is found. The mining pits have disturbed extensive patches across the landscape and have decreased available grazing lands, communal cropland, and reduced tree and vegetation density.

Runoff from pits and deposition into the dam is common and was observed in the field firsthand during rains and by the presence of rill erosion. This is particularly concerning given the intensity of rains in the wet season which have high splash erosion and transport potential. Soil piling around mining pits extends the height of each pit adding to the uneven verticality of a generally flat grassy rangeland. Not only an eyesore and source of soil transport, but several community members noted their danger having had livestock lost in them, drowning in the bottom of deep pits unable to climb out of their muddy and steep embankments. Two others described animal rescues from similar mining pits. Older pits are being reclaimed by infilling and scattered colonizing pioneer species such as grasses, forbes, and other herbaceous vegetation, though, the process appears very slow.

In the interest of community health and preservation of dam functionality, it has become the responsibility of community members to enforce zero tolerance of galamsey unless it is on one's own

Figure 8. Galamsey miners near Savannah

property which adheres to customary law. Several male community members noted that protecting land from miners can be dangerous for community members and yet still ineffective. The DCE admitted that local police were only occasionally involved because miners were not easily dissuaded but would quickly return. Even within the core of the community, I observed metal detecting and shallow prospecting just 300 m east of the dam in common grazing lands, though it was unclear who owned the land they were on, and what would happen if gold were found. The inability of the community to effectively manage galamsey within its own territory is concerning to both community members and local State officials.

Galamsey continues to negatively impact ecological and social systems yet there is no coherent solution. The DCE referenced meeting with local chiefs in her district to persuade more discussion with their respective community members to end galamsey, but she was unclear as to the overall effect of these actions. When miners do leave a galamsey site, they move to a new location until they are

Figure 9. Younger galamsey pits.

discovered and must leave again creating a constant cycle of ecological disturbance and economic insecurity. Their destructive profession comes at a cost to local ecologies and natural resources, but as of now, may be their best choice for earning a basic income. The DCE referenced targeting galamsey by improvement of other economic means, such as developing the previously mentioned commercial mango and cashew farming. It is yet unclear whether the ineffectiveness of water projects including the 1V1D and/or other agrarian declines have propagated more widespread galamsey in the region, and consequently destruction of dams such as in Savannah. However, providing access to water resources or other less-destructive economic activities may discourage galamsey by providing lucrative and year-round activities for local peoples. Interviewing miners to better understand the push and pull factors that drive their livelihood decisions could help source some of the root causes of their choices which are destructive to both farming and water systems.

4.3.1 Galamsey and Malaria

Where pits persist and water collects, risk for malaria vector or other waterborne illness have been documented.

> There's so much[sic] mosquitos now because of the dam. They disturb me a lot since my house is close to it. Without the net, we cannot sleep. Everybody in my house uses it. If not, we would have died of malaria. The mosquitos are too many now. (Community Member)

In my interview with the district health coordinator, concerns were raised regarding standing water in pits and in the dam. Standing water in this area increases risks for breeding grounds of malaria-vector mosquitos. They note that in 2021 and other years in the past, the pits were sprayed to destroy detected mosquito larvae, however, the dam has not been assessed nor treated. Even still, they stated that in the Nabdam district, malaria cases have been increasing particularly in the rainy season which

Figure 10. Galamsey pits adjacent to dam and spillway in mid-August 2022.

has increased the need for other medical interventions. The positive correlation between the rainy season and mosquito and thus malaria prevalence is in line with other recent studies in the area (Babayara & Addo, 2018). Community perceptions of a relationship between the dam and malaria cases were mixed, with just over one-third of participants associating the dam with more mosquitoes and malaria. It still remains inconclusive as to the effects of the dam and galamsey pits on mosquito populations at my field site but also warrants more testing.

4.4 Climate Change is Experienced Differently by Farmers than the Trends Meteorological Data Demonstrate

The effects of climate change are uniquely experienced by smallholder farmers in diverse and complicated ways. The ways in which farmers *measure* trends and changes are distinctively situated based on a multitude of social, historical, and environmental factors that can be used as alternative proxies. Meteorological data, by contrast, is objectively measured in regular intervals and in standardized scientific fashion. While each method of observation has its advantages and disadvantages, both are uniquely useful in climate research. For example, farmers may have general perceptions of trends over time because their lived experiences are in synch with their climate, yet they may also be swayed by anomalous events (Meze-Hausken, 2004). On the other hand, weather station data may be quite accurate, but by capturing data in a single location, particularly when few stations exist, trends can be more difficult to predict because data are localized to just those weather stations. This is especially important in regions where interannual or spatial variability is high, or weather station data is missing. In the field of climate change and agrarian adaptation, farmer perceptions of changing conditions are generally based on mean changes to temperature and precipitation, and their relative timing (Amadou et al., 2015). Although I did not collect data from farmers on temperature changes, this variable is typically more stable and broadly predictable than precipitation over long time-series.

Mean annual maximum and minimum temperatures at both weather stations show consistent increases in their respective time-series (Figure 11). This was also the case for total annual precipitation at both stations between 1980 to 2020. The Bolgatanga station reports an almost 1.0°C increase in mean maximum temperatures, but only a 0.3°C for mean minimum temperatures between 1980 and 2020. Zuarungu reports about a 0.4°C increase in mean maximum temperatures from 1990 to 2020, and a 0.5°C increase in mean minimum temperatures between 1990 and 2017. Although my data is within the acceptable limits of World Meteorological Organization standards (2017), much of the missing data in Bolgatanga was between 2013 and 2020 which may have influenced the mean maximum temperature more given the overall warming trend. Additionally, more data was missing during the rainy season when temperatures are lower which may have led to a warmer bias. The highest temperatures during the year are during the dry season period. Having additional local weather stations and testing data between them or collating would have improved statistical precision.

One challenging aspect of measuring rainfall in this region is the high interannual and spatial variability. While the region has a seasonally unimodal rainfall pattern, the nature of convective storms can have localized effects which may lead to two nearby communities receiving different rainfall totals from a single event, or even annually (Figure 12). Due to these effects and the distance between weather stations and my field site, these results can be generalized to my field site, but also highlights

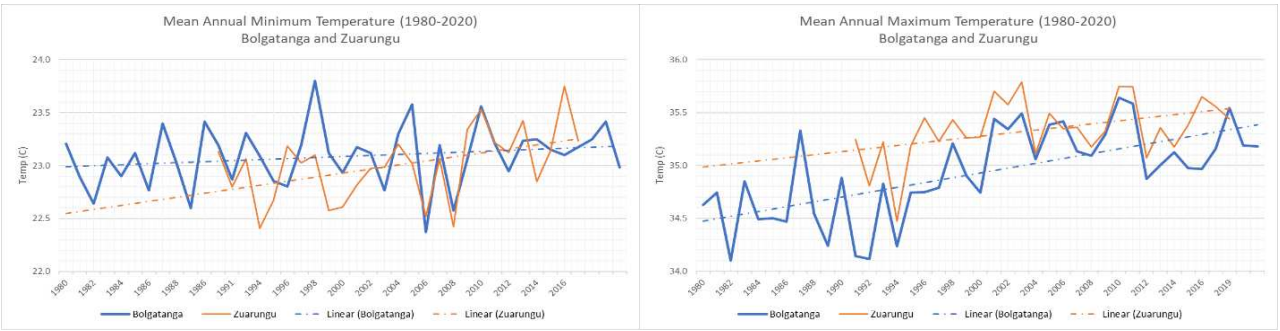

Figure 11. Mean annual minimum and maximum temperatures with trendlines for Bolgatanga and Zuarungu weather stations.

the need for more localized weather tracking in climate zones with higher intra-annual variability so that data can be interpolated. At the Bolgatanga station, the highest total annual rainfall was 1,382 mm in 2019 and the lowest was 742 mm in 1981 for an overall difference of 640 mm. In Zuarungu, the highest annual rainfall was 1,464 mm in 2007 and lowest was 690 mm in 1994 for a difference of 774 mm. Precipitation data and timing do not always correspond between the two weather stations, despite being only six kilometers away from one another. For similar reasons, it is clearly important to identify dispersed communities of interest to capture spatio-temporal climate data at a finer scale.

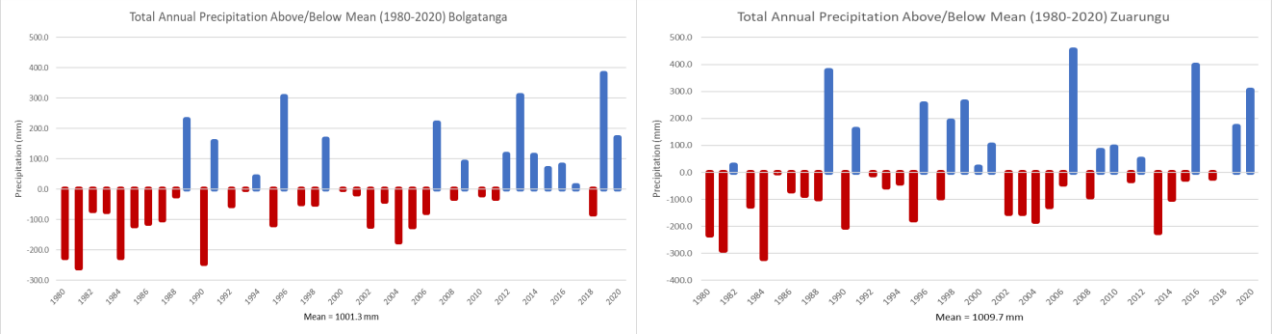

Figure 12. Difference in precipitation as compared to the mean for Bolgatanga and Zuarungu weather

4.4.1 Comparing Climate Data and Participant Perceptions

Although participants struggled to definitively answer whether there is more annual rainfall now as compared to when they were younger, they were willing to provide insight in terms of timing and intensity. Given the qualitative nature of the questions, participants were asked to compare rainfall patterns based on recent years versus times of their youth or in their younger years dependent on the age of our participant. Meze-Hausken's (2004) interviews with pastoralists in Ethiopia used interview language such as "your father's time" to elicit responses from 20-30 years prior. My goal was also to elicit similar responses drawing on memories from the participants' young adulthood or younger years.

Of the 26 interviews where participants responded to climate questions[5], 22 participants believed there have been changes to rainfall, two did not, and two did not respond or were unsure.

One of the most interesting observations regarding precipitation was related to its timing. Both weather stations recorded an increasing annual precipitation trend, but this also varies greatly from year to year and seasonally. For smallholders and subsistence farmers in particular, the start and end of the rainy season are crucial windows of opportunity for sowing and harvesting respectively. Additionally, timing of rains during the season is also important. Any unexpected variation in weather can have dire consequences on the health of crops and soils, yields, and food security. For example, inconsistent onset of the rainy season can cause false starts to the growing season leading to early crop failures or partial losses (Amadou et al., 2015). However, the addition of a stable and expansive water source such as a dam could remedy the effects of these inconsistencies if properly designed and managed. Sufficient dam water carryover from the previous rainy season could be key to consistent sowing and thus harvest dates, assuming irrigation infrastructure is in place and adequate. As per interviews, the dam in Savannah is consistently full during the majority of the rainy season, spilling valuable water which could be stored and used to extend the growing season and minimize losses during onset and end of the rainy season.

Although participant perceptions on the start and end of the rainy season were generally cohesive, part of the challenge with qualitative research and interviewing, especially when drawing on participant memories, is that they are not always as temporally specific as researchers would like. To account for participants who were less specific, I added categories that reflected seasonal changes rather than requiring exact timing of those changes. More specifically, regarding the beginning of the

[5] I did not interview State officials about their climate perceptions.

rainy season, when participants were unsure of start dates, they commonly answered, 'starts late' and 'it varies'. Correspondingly, for questions about the end of the season rains, 'ends early' and 'it varies' were also common responses. 'It varies' responses are open to interpretation because while it does indicate change, at least interannually, this type of high interannual variation is the normal for the region. Adding these categories allowed me to include less specific, but still useful data. Similarly, participants regularly answered that rains started and ended in between two different months and thus inter-monthly categories were added to reduce lumping bias.

Of the 24 participants measured, 17 believed that rains in recent years started after May, or at least later than in their younger years. Most agreed that the rains earlier in their lives began between March and May. This is key context for the utility of the Savannah's dam given that one of the 1V1D initiative's main purposes is to bridge the wet and dry seasons. Not only is the dam dry prior to the consistent start of the contemporary rainy season, but its adequacy would have likely been a stretch even 40 years ago, particularly since it is not even used for dry season gardening. For end of season rains, most participants reported that when they were younger, rains would end in November or even later, and nowadays rains end early, specifically between September and October, with four responding that it varies. These results signal more generally, a perception that rains are now ending earlier and starting later than compared to when participants were younger leading to an overall shorter growing season. Decreased rainfall predictability and agrarian outcomes in more recent years was clear:

> [Before], it was predictable and rained very well and fine. Farmers had much yield of all crops they grew. [The] same cannot be said of today. The yield has reduced. The rain today stops early and we suffer to uproot the groundnut – that is why we prefer those [cultivars] that mature faster. Our fathers used to grow all types of crops like those that mature early and late but now we cannot.

Another reiterated:

> We plant very late. At times, the rain will come and break for some time and we cannot plant our crops. By the time the rain is consistent, it's almost halfway [through] the season so the rain will stop when our crops are not ready for harvesting.

Interestingly, according to meteorological data, beginning and end of season rains are increasing and mid-season rains seem to be decreasing or remaining steady (Figure 13). If also true in Savannah, this could be good news for water availability and dam capture in both the early and late periods of the rainy season, however limited the dam's capacity is. There is strong agreement between station data and participants that rains used to begin in March and April, however, unlike most participants, the trend has continued albeit with high interannual variability (Figure 13). In fact, in the last 10 years, there have been quite high levels of early season rainfall which is counter to participant responses. May totals have increased by about 100 cm since 1980 and June totals have actually decreased slightly, yet participants most often report these two months as the current start of the rainy season.

Station data for end of season rainfall show very little rain in November, and even less in December across the entire time-series. This contradicts the majority of participants' views on when the rainy season would end in the past. However, station measurements do indicate participants' perceptions on the end of the season nowadays are quite accurate. Most participants agreed that rains end between September and October, or end early which the station data clearly indicates. Participants may view the start and end of the rainy season as less predictable and so difficult to pin down exactly when it begins and ends, especially interannually and over the course of several decades. Despite this, one way they have adapted to variability has been by converting to faster maturing crops, most commonly maize. White and red millets are still equally relied upon and appear to be successful. However, 10 participants described heavy yield losses of staple groundnuts due to desiccated soils during harvest caused by the variability of end of season rains. As part of variability, more than one-third of participants also felt that rainstorms were more intense now as compared to before suggesting that while they did not know if more annual precipitation was occurring, it was clear that more rain was

falling in a shorter amount of time with damaging effects to homes and crops. Although the dam in Savannah cannot mitigate storm intensity, with proper irrigation, it could supplement water deficits, and more specifically, reduce groundnut losses during harvest.

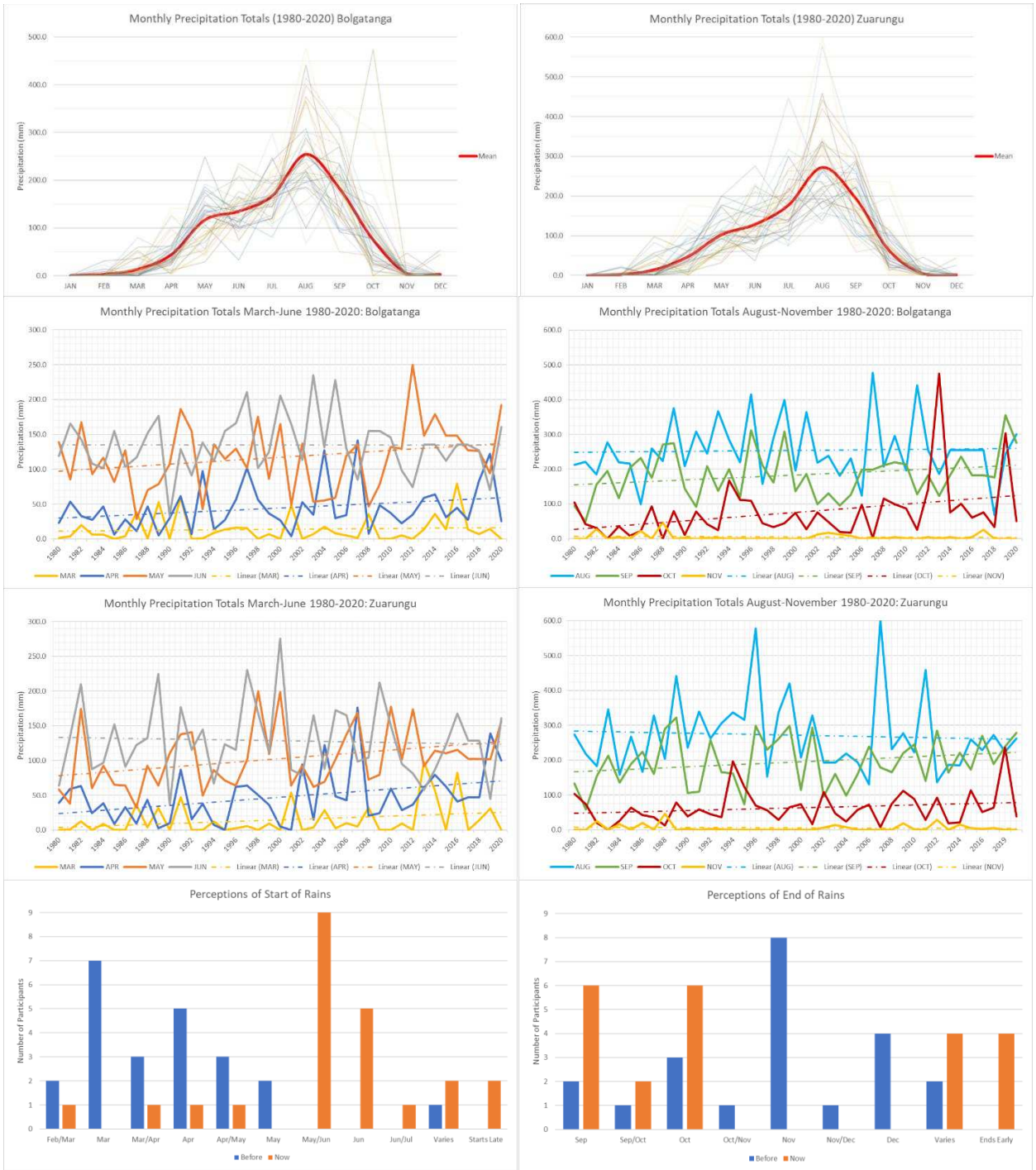

Figure 13. Annual monthly precipitation totals and means (top), early and late rainy season totals with trendlines for Bolgatanga and Zuarungu weather stations (middle), and participant perceptions of start and end of the rainy season (bottom).

4.4.2 Further Exploring the Discrepancies Between Farmer Perceptions and Climate Data

There are many potential causes for the discrepancy between station data and farmer perceptions of change and this should be explored in future studies due to their innate complexity in my region of interest. These can include higher temperatures increasing potential evapotranspiration, evaporative demand and thus desiccation (Baffour-Ata et al., 2021), high variability early in the season causing false starts to the growing season (Amadou et al., 2015), and new (and unfamiliar) crops and systems that demand novel techniques and nutrient supplementation as I witnessed in the field. Even gender has been found to affect perceptions of climate change (Kisauzi et al., 2012) which certainly involves local gender norms of unevenness and distribution of labor. I would expect interannual variability to have social or ecological carryover effects from previous years, including those related to vulnerability and gender. For example, food insecurity one year may result in subsequent insecurity in following years, particularly for those with less resources or support to begin with. As such, climate change perceptions have also been linked to social-ecological vulnerability and economic resilience (Meze-Hausken, 2004). Certainly, the resilience that comes with having proper access to a supplemental water source such as a 1V1D dam could impact farmer perceptions if the water capacity and access is notably sufficient to offset scarcity and hardship. So far, this does not seem to be the case in Savannah as evidenced by continued concern for changing climate conditions and a disappointing dam project.

Although participants in Savannah did not express knowledge of global climate changes, many associated variability and perceived decreases in rainfall with the long-term loss of trees and specific cultural traditions. These beliefs are consistent with other communities in the northern regions of Ghana (Bezner Kerr et al., 2022). Numerous participants discussed religious practices related to the funeral season as a cause for decreased or more sporadic rainfall and food insecurity. Those that adhere to customary beliefs suggest that farming before the end of the funeral season as scheduled by the Tindaan (Earthpriest) would result in angered gods and consequently poorer rains. Interestingly, other

non-adherents to these beliefs contend that funerals delayed sowing of seeds late into the start of the growing season resulting in lower yields and more food insecurity. To add to these countering arguments, the community allows fenceless free ranging of livestock before regular rains occur. Farmers that sow early thus risk loss of seedlings until animals are more widely penned or tied down.

Tree loss was mentioned by many participants as both a cause and effect of changing climate. Tree loss from age, galamsey, charcoal production and cooking, windthrow from more intense storms, and from felling for an electrification development project were all cited as reasons for changes to rainfall patterns. Wood for construction and tool making were not cited, but these uses were observed in the field.

Increasingly intense storms in recent years were referenced as causes of more tree loss suggesting a perceived feedback loop whereby fewer trees decreases windbreak. There is clearly tension between contemporary farming practices, agro-spirituality, development, and modernization that requires more research and distinct data comparisons.

Case studies of climate perceptions compared to meteorological measurements show mixed results regarding how well farmers perceive climate specific data correctly. In a recent study in the Ashanti Region in Ghana, smallholder farmers perceived similar trends to those measured by regional meteorological data (Asare-Nuamah & Botchway, 2019). While nuanced and in some cases non-significant, their lived experiences confirmed the changes in rainfall, temperature, and their respective intensities. Baffour-Ata et al. (2021) found that while their subjects' perceptions on rising temperatures and increasing rainfall variability were correct, rainfall totals are not increasing as the subjects perceived.

In another study in the UER of Ghana, Amadou et al. (2015) found that their subjects correctly identified increasing minimum and maximum temperatures, but incorrectly perceived that rainfall was

decreasing – meteorological data showed no changes. These farmers also correctly detected a later start date of the rainy season, but incorrectly perceived an earlier end of the season when meteorological data showed rainfall ending later as compared to earlier years (Amadou et al., 2015). They concluded that changes to the start of the growing season impacts end of season yields and that farmers place greater importance on intra-annual variability of the rainy season such as intensity and dry spells, which does not account for long-term trends (i.e., inter-annual variability) recorded by weather stations (Amadou et al., 2015). Their study also does not account for development initiatives such as damming projects that can mitigate both inter- and intra-annual variability. Like my own, theirs demonstrated experiential homogeneity among farmer community members as to how they view their climate changing, and what actions they can take to adapt. This prompts the obvious question of variability in answers from different age groups regarding conditions of the past in my own sample group. There is research on comparing memories from older and younger adults including with weather forecasts (see Gallo et al., 2019). Despite interesting results, we were not able to fully address these age-related biases in the field, however, they offer opportunity for future research design.

Since yields are directly connected to climate, the environment, politics, and socioeconomic factors, it is reasonable to consider that perceptions of climate change are also filtered through an equal myriad of lenses and variables. Perhaps further adding to these sometimes-incongruent perceptions is the inter-annual variability in precipitation, and to some degree temperatures, leading to unpredictable and even hazardous weather conditions for sustained agricultural production (Yaro & Hesselberg, 2016). Changes to the conditions of materiality have experiential consequences that further shape human and non-human entities and the spaces in which they engage. Importantly, smallholder perceptions of climate change are highly varied across the literature and researchers are beginning to incorporate interdisciplinary approaches to understand farmer knowledge and adaptation, including in macro-assessments such as those produced by the IPCC (Ayanlade et al., 2017).

One final thought for the relations between climate change and smallholders, is the access and usefulness of climate data. Curiously, with the exception of the DCE who referred to it in passing, not a single participant mentioned contemporary global climate change at any point in my interviews. Perhaps it is fair to ask, 'why would they?' if it is irrelevant to their daily lives and do not have applicable climate data. Widespread downscaling of climate data remains a lofty target with limitations on practicality for those that cannot access it, or have no use for it. On the flip side of this research, are the experiences remembered and retold by elders and the need for future generations to learn adaptation and novel strategies rooted in generational experiences and applied in modern contexts. Perhaps generational records can supplement meteorological data to improve resilience and self-directed development. Or perhaps it can enhance missing climatological data if placed in the right context for accurate recounting. In both cases, collaborative efforts between institutions, researchers, and local peoples can have powerful effects to improve community-level (and community-directed) well-being through integration, mutually beneficial reciprocity, and relevant data sharing.

5 CONCLUSION

Under the 1V1D initiative, the State set an ambitious goal to build over 500 new dams in the northern regions of Ghana. Like many projects of this scale, a single metric cannot capture its success or failure, and each individual dam falls somewhere in a multi-dimensional measurement of success based on political, social, and ecological reasons. Perhaps the state of the overall initiative has been purposefully obscured in favor of a politically-driven success story. Literature on the project, thus far, has been mainly relegated to news agencies and public opinion indicating a need for robust research on the project at all dam sites. Further, outside politicized information from State websites, news agencies, and social media, I found little public data reported on dam locations and detailed results from this initiative.

In my research, I report on just one site, but it does elucidate the process of implementation and results that followed which are underwhelming to community members. By capturing interview data from a subpopulation of community members, I report perspectives from actual dam users. By interviewing State officials, formal bureaucratic pathways and opinions from public leaders provides *some* State insight. In the end, this thesis set out to expand knowledge with three primary goals: to better recognize how the community understands and uses their 1V1D dam and the social and ecological effects linked to the dam, how it impacts community agriculture, and how the initiative articulates with both climate change data and farmer perceptions on climate change.

The interviewed community members in Savannah have made clear the severe limitations of the dam and of how the 1V1D initiative was locally implemented. The State's performative intervention sullied the hope of community members before it was even completed, constructing a mirage with unexpected social and ecological impacts. After its completion, the dam has not improved water

insecurity in the dry season for farming and livestock, and has not reduced livelihood burdens including out-migration or food insecurity. Most participants relayed that the dam is infilling through multiple and preventable causes. Small-scale gold mining is clearly a destructive source of deteriorating community spaces, including the dam, and remains a key area of concern for the community and their social-ecological relations. And the dam has little mitigating effect on water deficits and challenging climate conditions, both now and in the future.

My analysis therefore suggests that the inequities between the State and community of Savannah have been further embedded in the political actions of federally-appointed decision-makers, resulting in disingenuous and insensitive social-ecological development. Politics are consistently embedded in agroecological reform, and the dam has clearly created new social-ecological relations including increased health risks to livestock and humans with little overall hydrological benefit. Novel crocodile incidents and malaria vectors were unexpected and unresolved issues created by State leaders, but suffered by community members. In other ways, the dam has not altered community engagement with challenging agrarian and ecological conditions such as water and food shortages, drought, and declining farming systems.

In sum, participant concerns were primarily related to destruction and hazards from galamsey, dry season farming and water scarcity, food security, and adaptation to altered climate norms and consequently novel farming and growing conditions. I found little evidence that these concerns have been addressed by the State with any seriousness highlighting the political-ecological overlap through embedded inequities, false narratives and knowledge production, and enforced compliance of top-down modernizing development. Considering the scale of the 1V1D project and the limited data that exists publicly, there are serious political questions as to its implementation, motives, and who the actual beneficiaries are. The 1V1D initiative seems ill-equipped to handle the grand scale of so many distinctive community prerogatives. To uniquely construct hundreds of locally utilized dams in specific social-

ecological spaces in such a rapid timeframe suggests an overtly ambitious mission uninformed of diverse community needs and the contexts therein. The president's canvassing efforts to develop northern regions are noteworthy, but serious questions as to the implementation and transparency of such development efforts remain.

Climatologically, comparisons of community perceptions on climate and weather station data were mixed overall. Temperatures and overall precipitation are both increasing at Savannah's two nearest stations, but changes to the timing of rains and high interannual variations seems to make discerning patterns difficult for the sampled community members. Still, these innate variations support mitigating interventions such as a well-designed water project with community involvement to promote agricultural and socioeconomic resilience. Extended community involvement in the dam's development and their climatological perspectives could have resulted in a more successful outcome with greater mitigative effects.

Furthermore, these types of studies elucidate the implications of farmer-experience proxies on perceptions of long-term climate data. In the broad-scale of global change rhetoric, comparative studies are valuable and provide the opportunity to scale down climate effects in new and interesting ways. Traditions are rooted in historical context which is critical for long-term climate theory. Learning from Indigenous or community groups can also provide the basis for research on better adaptation strategies and improving resilience in more inclusive and bottom-up ways. It is also important to avoid data extraction research and promote ongoing improvements to researcher-community collaborations with improved application of coproduced and applicable knowledge. We share a world space, and so should share ideas with humility and for the success of our social and ecological systems. In the case of my own research, many participants expressed their concerns as well as ideas for further development, which were most often outside the scope of my thesis. Although I cannot address them all, which leaves a

lingering feeling for more involvement, I have included them below to document and direct future research.

6 COMMUNITY-DRIVEN INSIGHT FOR FUTURE DEVELOPMENT

My conversations with community members highlighted their creativity and eagerness to adapt to new and unique methods of farming and livelihood strategies. As many farmers in Savannah describe, in recent years, they have shifted to new types farming systems and crops. As some participants have shifted toward agrochemical use, a broader concern was not only of access to herbicides, pesticides, and fertilizers, but of proper use and accessibility of safety equipment. Among participants, there is a common knowledge of the longer-term effectiveness of natural manure on soil and therefore crop health as compared to chemical fertilizers. However, there is also a limited supply of manure and some farmers have grown dependent on chemicals, but without the funds to purchase them. This is similarly the case for herbicides where farmers have simultaneously limited capacity for weeding and purchase power for these inputs. These conditions have left farmers to rotate their crops and grow maize, their latest cultivar addition and most nutrient depleting crop, on their most fertile soils. Further, crop losses and common fallowing are sometimes unavoidable, but also may hinder food security efforts from decreased yields.

With greater access to diverse fertilizers, farmers would expect to decrease their food insecurity. However, these conditions are also set in the context of erratic and unpredictable rainfalls, novel Fall Armyworm (*Spodoptera frugiperda*) outbreaks on maize crops, and widespread livestock disease. The MoFA agricultural officer also noted outbreaks of Avian Flu and African Swine Fever. Interviews with community members indicated maize specific pests and extensive poultry deaths and moderate loss of pigs which were of major concern to food and economic security. Participants were all unclear as to the extensive cause of death of their animals, and were simply instructed by MoFA to bury and not consume these animals. Fall Armyworm outbreaks were not widely reported by participants.

However, according to the Nabdam district's agricultural officer, MoFA's declining funding from the *Modernizing Agriculture in Ghana* program funded by the Canadian Partnership for Women and Children's Health (2023) has limited their ability to institute standard disease protocols and manage any of these.

The community listed a number of primary concerns and needs to improve farming and yields. Development ideas from participants were diverse and clearly in line with agroecological approaches combining traditional and modern practices. These include developing overall better access to clean water, improving food security, economic security, and improved crop and livestock health. Participants are also interested in adding more, and adding electric boreholes with raised cisterns for water storage, increasing the height of the dam for improved water capacity, development of irrigation including channels or pipelines, training for agrochemical safety and application as well as better access to all types of fertilizers. Additionally, they seek training for composting and food storage for dry season livestock feed including sileage, livestock disease testing and vaccinations, training on best animal husbandry practices, and better outreach from the agricultural officers for disease control, experiments, and farming best practice training. Much of the need is related to dry season farming as participants at large expressed the need for food and economic access between harvest and sowing. There is also growing concern for worsening human health issues including malaria and Lymphatic filariasis, as well as malnutrition, anemia, and kwashiorkor. While the list is long, their strong desire to understand and implement modern and sustainable methods is deeply rooted and shows strong community cohesion to improve their well-being over the long term.

REFERENCES

Abanyie, S., Sunkari, E. D., Apea, O. B., Abagale, S., & Korboe, H. M. (2020). Assessment of the quality of water resources in the Upper East Region, Ghana: a review. *Sustainable Water Resources Management*, 6(4). https://doi.org/10.1007/s40899-020-00409-4

Acheampong, E. N., Ozor, N., & Sekyi-Annan, E. (2014). Development of small dams and their impact on livelihoods: *Cases from northern Ghana*.

Acheampong, M. (2020). " Critical Ecosystems" as a concept in political ecology–developing a comprehensive analytical framework. *Journal of Political Ecology*, *27*(1), 190-212.

Agyeman, K., & Bruce, E. (2021, February 19). *426 dams build under One Village, One Dam initiative – Hawa Koomson*. Graphic Online. https://www.graphic.com.gh/news/general-news/426-dams-built-under-one-village-one-dam-initiative-hawa-koomson.html

Akhter, M. (2015). Infrastructure nation: State space, hegemony, and hydraulic regionalism in Pakistan. *Antipode*, 47(4), 849-870.

Akhter, M. (2022). Dams, development, and racialised internal peripheries: Hydraulic imaginaries as hegemonic strategy in Pakistan. *Antipode*, 54(5), 1429-1450.

Altieri, M. A., Funes-Monzote, F. R., & Petersen, P. (2012). Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agronomy for Sustainable Development*, 32(1), 1–13. https://doi.org/10.1007/s13593-011-0065-6

Amadou, M., Villamor, G., Attua, E., & Traore, S. (2015). Comparing farmers' perception of climate change and variability with historical climate data in the Upper East Region of Ghana. *Ghana Journal of Geography.* 7(1). 47 – 74.

Andersson, E., Brogaard, S., & Olsson, L. (2011). The Political Ecology of Land Degradation. *Annual Review of Environment and Resources*, 36(1), 295–319. https://doi.org/10.1146/annurev-environ-033110-092827

Andrade, C. (2021). The inconvenient truth about convenience and purposive samples. Indian Journal of *Psychological Medicine*, 43(1), 86-88.

Antwi-Agyei, P., Stringer, L. C., & Dougill, A. J. (2014). Livelihood adaptations to climate variability: insights from farming households in Ghana. *Regional Environmental Change*, 14(4), 1615–1626. https://doi.org/10.1007/s10113-014-0597-9

Antwi-Agyei, P., Dougill, A. J., Stringer, L. C., & Codjoe, S. N. A. (2018). Adaptation opportunities and maladaptive outcomes in climate vulnerability hotspots of northern Ghana. *Climate Risk Management*, 19, 83–93. https://doi.org/10.1016/j.crm.2017.11.003

Apinga, D. (2020, July 9). *Our Dams Are For Modern Irrigation – Gov't Debunks Peasant Farmers Report.* The Ghana Report. https://www.theghanareport.com/our-dams-are-for-modern-irrigation-govt-debunks-peasant-farmers-report/

Asamoah, K. (2019, October 8). *1V1D project abandoned in Savalugu after sod-cutting*. The Ghana Report. https://www.theghanareport.com/1v1d-project-abandoned-in-savalugu-after-sod-cutting/

Asare-Nuamah, P., & Botchway, E. (2019). Comparing smallholder farmers' climate change perception with climate data: the case of Adansi North District of Ghana. *Heliyon*. 5. https://doi.org/10.1016/j.heliyon.2019.e03065

Assahira, C., Piedade, M. T. F., Trumbore, S. E., Wittmann, F., Cintra, B. B. L., Batista, E. S., , A. F. de, & Schöngart, J. (2017). Tree mortality of a flood-adapted species in response of hydrographic changes caused by an Amazonian river dam. *Forest Ecology and Management*, 396, 113–123. https://doi.org/10.1016/j.foreco.2017.04.016

Ayanlade, A., Radeny, M., & Morton, J. F. (2017). Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. *Weather and Climate Extremes*, 15(C), 24–33. https://doi.org/10.1016/j.wace.2016.12.001

Ayelazuno, J. (2014). The "new extractivism" in Ghana: A critical review of its development prospects. *The Extractive Industries and Society*, 1(2), 292–302. https://doi.org/10.1016/j.exis.2014.04.008

Ayers, J., & Dodman, D. (2010). Climate change adaptation and development I: the state of the debate. *Progress in Development Studies*, 10(2), 161–168. https://doi.org/10.1177/146499340901000205

Babayara, M., & Addo, B. (2018). Presumptive Treatment of Malaria in Ghana: Was It Ever Useful? Evidence from the Kassena-Nankana District of Northern Ghana. *Malaria Research and Treatment*, 2018, 3408089–6. https://doi.org/10.1155/2018/3408089

Baffour-Ata, F., Antwi-Agyei, P., Apawu, G. O., Nkiaka, E., Amoah, E. A., Akorli, R., & Antwi, K. (2021). Using traditional agroecological knowledge to adapt to climate change and variability in the Upper East Region of Ghana. *Environmental Challenges*, 4, 100205–. https://doi.org/10.1016/j.envc.2021.100205

Berkes F. (2017). Environmental Governance for the Anthropocene? Social-Ecological Systems, Resilience, and Collaborative Learning. *Sustainability*. 2017; 9(7):1232. https://doi.org/10.3390/su9071232

Bezemer, D., & Headey, D. (2008). Agriculture, Development, and Urban Bias. *World Development*, 36(8), 1342–1364. https://doi.org/10.1016/j.worlddev.2007.07.001

Bezner Kerr, R., Naess, L. , Allen-O'Neil, B., Totin, E., Nyantakyi-Frimpong, H., Risvoll, C., Rivera Ferre, M., López-i-Gelats, F., & Eriksen, S. (2022). Interplays between changing biophysical and social dynamics under climate change: Implications for limits to sustainable adaptation in food systems. Global Change Biology, 28(11), 3580–3604. https://doi.org/10.1111/gcb.16124

Black, R., Adger, W. N., Arnell, N. W., Dercon, S., Geddes, A., & Thomas, D. (2011). The effect of environmental change on human migration. *Global Environmental Change*, 21, S3–S11. https://doi.org/10.1016/j.gloenvcha.2011.10.001

Boulton, D., & Hammersley, M. (1996) *Analysis of Unstructured Data. Data Collection and Analysis*, R. Sapford, V. Jupp, Eds. Sage Publications.

Canadian Partnership for Women and Children's Health. (2023). *Modernizing Agriculture in Ghana.* https://canwach.ca/project/modernizing-agriculture-in-ghana/#:~:text=Return%20to%20top-,Description,and%20modernize%20agricultural%20extension%20services.

Carr, E. (2005). Placing the environment in migration : environment, economy, and power in Ghana's Central Region. *Environment and Planning*. A, 37(5), 925–946. https://doi.org/10.1068/a3754

Cole, M., Elliott, R. J. ., & Strobl, E. (2014). Climate Change, Hydro-Dependency, and the African Dam Boom. *World Development*, 60, 84–98. https://doi.org/10.1016/j.worlddev.2014.03.016

Crescenzi, R. & Rodríguez-Pose, A. (2011). Reconciling top-down and bottom-up development policies. *Environment and Planning*. A, 43(4), 773–780. https://doi.org/10.1068/a43492

Demi, S., & Sicchia, S. R. (2021). Agrochemicals Use Practices and Health Challenges of Smallholder Farmers in Ghana. *Environmental Health Insights*, 15, 117863022110430–11786302211043033. https://doi.org/10.1177/11786302211043033

Dinko, D.H., & Nyantakyi-Frimpong, H. (2022). A Drone Photo-Elicitation Approach to Researching Legal Pluralism in Natural Resource Access. *Society & Natural Resources*, 35(11), 1246–1255. https://doi.org/10.1080/08941920.2022.2107749

Dinko, D.H., Yaro, J., & Kusimi, J. (2019). "Political ecology and contours of vulnerability to water insecurity in semiarid northern Ghana." *Journal of Asian and African Studies*, 54(2), 282-299

Electoral Commission of Ghana. (2022). *2020 Presidential Results*. https://ec.gov.gh/2020-presidential-election-results/#

England, K. V. (1994). Getting personal: Reflexivity, positionality, and feminist research. *The professional geographer*, 46(1), 80-89.

Ersado, L. (2005). *Small-scale irrigation dams, agricultural production, and health - theory and evidence from Ethiopia.* World Bank Policy Research Working Paper 3494.

Esteva, G., Babcicky, P., & Babones, S. J. (2013). *The future of development: a radical manifesto*. Policy Press.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics*, 5(1), 1-4.

Fearnside, P. (2015). Amazon dams and waterways: Brazil's Tapajós Basin plans. *Ambio*, 44(5), 426–439. https://doi.org/10.1007/s13280-015-0642-z

Feed the Future (n.d.) *The Impact of Irrigation on Improved Productivity and Market Value for Smallholder Farmers in Northern Ghana*. Feed the Future Innovation Lab for Markets, Risk and Resilience. https://basis.ucdavis.edu/project/impact-irrigation-improved-productivity-and-market-value-smallholder-farmers-northern-ghana

Ferring, D., & Hausermann, H. (2019). The Political Ecology of Landscape Change, Malaria, and Cumulative Vulnerability in Central Ghana's Gold Mining Country. *Annals of the American Association of Geographers*, 109(4), 1074–1091. https://doi.org/10.1080/24694452.2018.1535885

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L., & Holling, C. S. (2004). Regime Shifts, Resilience, and Biodiversity in Ecosystem Management. *Annual Review of Ecology, Evolution, and Systematics*, 35(1), 557–581. https://doi.org/10.1146/annurev.ecolsys.35.021103.105711

Folke, C., Carpenter, S. ., Walker, B., Scheffer, M., Chapin, T., & Rockstrom, J. (2010). Resilience Thinking: Integrating Resilience, Adaptability and Transformability. *Ecology and Society*, 15(4), 419–.

Forsberg, B., Melack, J. M., Dunne, T., Barthem, R. B., Goulding, M., Paiva, R. C. D., Sorribas, M. V., Silva, J., & Weisser, S. (2017). The potential impact of new Andean dams on Amazon fluvial ecosystems. *PloS One*, 12(8), e0182254–e0182254. https://doi.org/10.1371/journal.pone.0182254

Fraser, E., Dougill, A. J., Mabee, W. E., Reed, M., & McAlpine, P. (2006). Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management*, 78(2), 114–127. https://doi.org/10.1016/j.jenvman.2005.04.009

Gallo, H. B., Hargis, M. B., & Castel, A. D. (2019). Memory for weather information in younger and older adults: Tests of verbatim and gist memory. *Experimental aging research*, 45(3), 252-265.

Ghana Meteorological Agency. (2022). Climate data for the Bolgatanga and Zuarungu synoptic stations. Ghana Meteorological Agency.

GNA. (2022, July 26). *Forty per cent of 1V1D dams didn't meet design – Research.* Ghana News Agency. https://gna.org.gh/2022/07/forty-per-cent-of-1v1d-dams-didnt-meet-designresearch/

Gwazani, R., Gandiwa, E., Gandiwa, P., Mhaka, V., Hungwe, T., & Muza, M. (2012). The socio-ecological impacts of small dams: A case study of Mushandike Sanctuary, Zimbabwe. *Journal of Sustainable Development in Africa*, 14(6), 184-194.

Halcomb, E. J., & Davidson, P. M. (2006). Is verbatim transcription of interview data always necessary?. *Applied nursing research*, 19(1), 38-42.

Haraway, D. (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies*, 14(3), 575–599. https://doi.org/10.2307/3178066

Hausermann, H. (2012). From polygons to politics: Everyday practice and environmental governance in Veracruz, Mexico. *Geoforum*, 43(5), 1002-1013.

Hausermann, H. (2014). Maintaining the coffee canopy: understanding change and continuity in Central Veracruz. *Human Ecology*, 42, 381-394.

Hausermann, H. (2018). "Ghana must Progress, but we are Really Suffering": Bui Dam, Antipolitics Development, and the Livelihood Implications for Rural People. *Society & Natural Resources*, 31(6), 633–648. https://doi.org/10.1080/08941920.2017.1422062

Hausermann, H., & Adomako, J. (2021). Positionality,'the field,'and implications for knowledge production and research ethics in land change science. *Journal of Land Use Science*, 17(1), 211-225.

Hausermann, H., Ferring, D., Atosona, B., Mentz, G., Amankwah, R., Chang, A., Hartfield, K., Effah, E., Asuamah, G. Y., Mansell, C., & Sastri, N. (2018). Land-grabbing, land-use transformation and social differentiation: Deconstructing "small-scale" in Ghana's recent gold rush. *World Development*, 108, 103–114. https://doi.org/10.1016/j.worlddev.2018.03.014

Holt-Giménez, E., & Shattuck, A. (2009). Smallholder Solutions to Hunger, Poverty and Climate Change.

Hunter, J. (2003). Inherited burden of disease: agricultural dams and the persistence of bloody urine (Schistosomiasis hematobium) in the Upper East Region of Ghana, 1959–1997. *Social Science & Medicine* (1982), 56(2), 219–234. https://doi.org/10.1016/S0277-9536(02)00021-7

Hunter, L. M., Luna, J. K., & Norton, R. M. (2015). Environmental Dimensions of Migration. *Annual Review of Sociology*, 41(1), 377–397. https://doi.org/10.1146/annurev-soc-073014-112223

Jarawura, F. (2021). Dynamics of Drought-Related Migration among five villages in the Savannah of Ghana. *Ghana Journal of Geography*, 13(1), 103—125. https://doi.org/10.4314/gjg.v13i1.6

Kaiser, M.S. (2020). Are Bottom-Up Approaches in Development More Effective than Top-Down Approaches? *Journal of Asian Social Science Research*, 2(1), 91–109. https://doi.org/10.15575/jassr.v2i1.20

Kisauzi, T., Mangheni, M. N., Sseguya, H., & Bashaasha, B. (2012). Gender dimensions of farmers' perceptions and knowledge on climate change in Teso sub-region, eastern Uganda. *African Crop Science Journal*, 20, 275-286.

Kleemann, J., Baysal, G., Bulley, H. N. ., & Fürst, C. (2017). Assessing driving forces of land use and land cover change by a mixed-method approach in north-eastern Ghana, West Africa. *Journal of Environmental Management*, 196, 411–442. https://doi.org/10.1016/j.jenvman.2017.01.053

Kumasi, T., Antiwi-Agyei, P. and Orbiri-Danso K. (2019). Small-holder farmers' climate change adaptation practices in the Upper East Region of Ghana. *Environmental Development and Sustainability*. 21:745–762.

Lasage, R., Aerts, J., Verburg, P. ., & Sileshi, A. (2015). The role of small scale sand dams in securing water supply under climate change in Ethiopia*. Mitigation and Adaptation Strategies for Global Change*, 20(2), 317–339. https://doi.org/10.1007/s11027-013-9493-8

Leech, N. L., & Onwuegbuzie, A. J. (2008). Qualitative data analysis: A compendium of techniques and a framework for selection for school psychology research and beyond. *School psychology quarterly*, 23(4), 587.

Li, T. (2005). Beyond "the state" and Failed Schemes. *American Anthropologist*, 107(3), 383–394. https://doi.org/10.1525/aa.2005.107.3.383

Li, T. (2007). The will to improve. New Durham, NC: Duke University Press.

Li, T. (2009). Exit from agriculture: a step forward or a step backward for the rural poor?. The *Journal of Peasant Studies*, 36(3), 629-636.

Li, T. (2013). Jobless growth and relative surplus populations (Respond to this article at http://www.therai.org.uk/at/debate). *Anthropology Today*, 29(3), 1-2.

Li, T. (2015). "Can there be food sovereignty here?." *Journal of Peasant Studies* 42.1: 205-211.

Lipson, J. (Ed.) (1991). *The use of self in ethnographic research*. SAGE Publications, Inc., https://dx.doi.org/10.4135/9781483349015

Marks, E., Aflakpui, G. K. S., Nkem, J., Poch, R. M., Khouma, M., Kokou, K., Sagoe, R., & Sebastià, M.-T. (2009). Conservation of soil organic carbon, biodiversity and the provision of other ecosystem services along climatic gradients in West Africa. *Biogeosciences Discussions*, 5(6), 4413–4452. https://doi.org/10.5194/bgd-5-4413-2008

McIntosh, M., & Morse, J. M. (2015). Situating and Constructing Diversity in Semi-Structured Interviews. *Global Qualitative Nursing Research*, 2, 2333393615597674–2333393615597674. https://doi.org/10.1177/2333393615597674

McMichael, P. (Ed.). (2010a). *Contesting Development: Critical Struggles for Social Change.* Routledge.

McMichael, P. (2010b). Introduction, Food, Energy, Environment: Crisis of the Modern World-System. *Review - Fernand Braudel Center for the Study of Economies, Historical Systems, and Civilizations*, 33(2/3), 95–102.

McMichael, P. & Morarji, K. (2010). Development and Its Discontents, In *Contesting Development: Critical Struggles for Social Change.* McMichael, P (Ed.). Routledge.

Meze-Hausken, E. (2004). Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia. *Climate Research*, 27(1), 19–31. https://doi.org/10.3354/cr027019

Mirzabaev, A., Sacande, M., Motlagh, F., Shyrokaya, A., & Martucci, A. (2021). Economic efficiency and targeting of the African Great Green Wall. *Nature Sustainability*, 5(1), 17–25. https://doi.org/10.1038/s41893-021-00801-8

Mitchell, T. (2002). *Rule of Experts Egypt, Techno-Politics, Modernity*. University of California Press.

Mohammed, K., Batung, E., Kansanga, M., Nyantakyi-Frimpong, H., & Luginaah, I. (2021). Livelihood diversification strategies and resilience to climate change in semi-arid northern Ghana. *Climatic Change*, 164(53). https://doi.org/10.1007/s10584-021-03034-y

Morton, J. F. (2007). The Impact of Climate Change on Smallholder and Subsistence Agriculture. *Proceedings of the National Academy of Sciences - PNAS*, 104(50), 19680–19685. https://doi.org/10.1073/pnas.0701855104

Mosso, C., Pons, D., & Beza-Beza, C. (2022). A Long Way toward Climate Smart Agriculture: The Importance of Addressing Gender Inequity in the Agricultural Sector of Guatemala. *Land*, 11(8), 1268–. https://doi.org/10.3390/land11081268

Naadi, T. (2022, November 17). *Ghana economy: Entrepreneurs struggle as cedi plunges and inflation rises.* BBC News. https://www.bbc.com/news/world-africa-63628352

Nega, B., & Schneider, G. (2014). NGOs, the State, and Development in Africa. *Review of Social Economy*, 72(4), 485–503. https://doi.org/10.1080/00346764.2014.958901

Nartey, L. (2022, January 11). *Gov't to complete all projects under one-village, one-dam initiative this year*. 3News. https://3news.com/govt-to-complete-all-projects-under-one-village-one-dam-initiative-this-year/

Niang, I., O.C. Ruppel, M.A. Abdrabo, A. Essel, C. Lennard, J. Padgham, and P. Urquhart. (2014): *Africa In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265

Nyantakyi-Frimpong, H., & Bezner Kerr, R. (2017). Land grabbing, social differentiation, intensified migration and food security in northern Ghana. *The Journal of Peasant Studies*, 44(2), 421–444. https://doi.org/10.1080/03066150.2016.1228629

Nyantakyi-Frimpong, H. (2020). What lies beneath: Climate change, land expropriation, and zaï agroecological innovations by smallholder farmers in Northern Ghana. *Land Use Policy*, 92, 104469. https://doi.org/10.1016/j.landusepol.2020.104469

O'Brien, K. L., & Leichenko, R. (2000). *Environmental change and globalization : double exposures*. Oxford University Press.

Omari, Bellingrath-Kimura, S. D., Addo, E. S., Oikawa, Y., & Fujii, Y. (2018). Exploring Farmers' Indigenous Knowledge of Soil Quality and Fertility Management Practices in Selected Farming Communities of the Guinea Savannah Agro-Ecological Zone of Ghana. *Sustainability*, 10(4), 1034. https://doi.org/10.3390/su10041034

Ostrom. E. (2009). General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science* (*American Association for the Advancement of Science*), 325(5939), 419–422. https://doi.org/10.1126/science.1172133

Özkaynak, B. (2019). Environmental justice, climate justice, and the green economy. *In Handbook of Green Economics* (pp. 93-116). Academic Press.

Parliament of Ghana. (2019). *One Village One Dam*. https://www.parliament.gh/news?CO=56

PeaceFmOnline (2020a). *General Elections 2012. Upper East Region.* https://ghanaelections.peacefmonline.com/pages/2012/uppereast/

PeaceFmOnline (2020b). *General Elections 2016. Upper East Region.* https://ghanaelections.peacefmonline.com/pages/2016/uppereast/

PeaceFmOnline (2020c). *General Elections 2020. Upper East Region.* https://ghanaelections.peacefmonline.com/pages/2020/uppereast/

Peet, R. (1985). The social origins of environmental determinism. *Annals of the Association of American Geographers*, 75(3), 309-333.

Perreault, T. 2012. Dispossession by Accumulation? Mining, Water and the Nature of Enclosure on the Bolivian Altiplano. *Antipode*: 1-21.

Perreault, T., Bridge, G., & McCarthy, J. (Eds.). (2020). Routledge handbook of political ecology. Routledge. https://doi.org/10.4324/9781315759289

Piguet, E. (2013). From "Primitive Migration" to "Climate Refugees": The Curious Fate of the Natural Environment in Migration Studies. *Annals of the Association of American Geographers*, 103(1), 148–162. https://doi.org/10.1080/00045608.2012.696233

Pilliod, D., Rohde, A. T., Charnley, S., Davee, R. R., Dunham, J. B., Gosnell, H., Grant, G. E., Hausner, M. B., Huntington, J. L., & Nash, C. (2018). Survey of Beaver-related Restoration Practices in Rangeland Streams of the Western USA. *Environmental Management* (New York), 61(1), 58–68. https://doi.org/10.1007/s00267-017-0957-6

Quinn, J. & Akyol, S. (2021). Ethiopian Foreign Policy: A Weak State or a Regional Hegemon? *Journal of Asian and African Studies (Leiden),* 56(5), 1094–1118. https://doi.org/10.1177/00219096211007649

Resende, A. F., Piedade, M. T. F., Feitosa, Y. O., Andrade, V. H. F., Trumbore, S. E., Durgante, F. M., Macedo, M. O., & Schöngart, J. (2020). Flood-pulse disturbances as a threat for long-living Amazonian trees. *The New Phytologist*, 227(6), 1790–1803. https://doi.org/10.1111/nph.16665

Ritchie, H., Eisma, J. A., & Parker, A. (2021). Sand Dams as a Potential Solution to Rural Water Security in Drylands: Existing Research and Future Opportunities. *Frontiers in Water*, 3. https://doi.org/10.3389/frwa.2021.651954

Robbins, P. (2001). Tracking invasive land covers in India, or why our landscapes have never been modern. *Annals of the Association of American Geographers,* 91(4): 637-659.

Robbins, P., Hintz, J. G., & Moore, S. A. (2014). Environment and society: a critical introduction (2nd ed). Wiley.

Rosenzweig, S., Fonte, S. J., & Schipanski, M. E. (2018). Intensifying rotations increases soil carbon, fungi, and aggregation in semi-arid agroecosystems. *Agriculture, Ecosystems & Environment*, 258, 14–22. https://doi.org/10.1016/j.agee.2018.01.016

Robinson, O. (2014). Sampling in Interview-Based Qualitative Research: A Theoretical and Practical Guide. *Qualitative Research in Psychology*, 11(1), 25–41. https://doi.org/10.1080/14780887.2013.801543

Robertson, M. (2020). Environmental Governance: Political ecology and the state, In *Routledge Handbook of Political Ecology*, Perreault, T., Bridge, G., & McCarthy, J. (Eds). Routledge Publication.

Schleeter, R. (2022). *The Great Green Wall – The Great Green Wall initiative uses an integrated approach to restore a diversity of ecosystems in the North African Landscape.* National Geographic. https://education.nationalgeographic.org/resource/great-green-wall

Scott, J. (1998). *Seeing Like a State*. New Haven: Yale University Press.

Smith, M. (2019, January 29). *Curbing Rural-Urban migration; The prospects of Gov't's 1V1D policy.* Ghana Broadcasting Corporation Online. https://www.gbcghanaonline.com/news/curbing-rural-urban-migration-the-prospects-of-govts-1v1d-policy/2019/

Smucker, T., Wisner, B., Mascarenhas, A., Munishi, P., Wangui, E. E., Sinha, G., Weiner, D., Bwenge, C., & Lovell, E. (2015). Differentiated livelihoods, local institutions, and the adaptation imperative: Assessing climate change adaptation policy in Tanzania. *Geoforum*, 59, 39–50. https://doi.org/10.1016/j.geoforum.2014.11.018

Sore, A. (2020, July 8). *90% of 1V1D dams cannot be used for irrigation purposes – Research Reveals.* My Joy Online. https://www.myjoyonline.com/90-of-1v1d-dams-cannot-be-used-for-irrigation-purposes-research-reveals/

Sumani, J. (2019). Possible Environmental and Socio-economic Ramifications of Sand and Gravel Winning in Danko, Upper West Region of Ghana. *Ghana Journal of Geography*, 11(2), 27-51.

Sun, L., Jaramillo, F., Cai, Y., Zhou, Y., Shi, S., Zhao, Y., Wang, W., Yi, Y., Yang, W., Yang, Z., Tan, Q., & Gunnarson, B. (2021). Exploring the influence of reservoir impoundment on surrounding tree growth. *Advances in Water Resources*, 153, 103946–. https://doi.org/10.1016/j.advwatres.2021.103946

Tang. C. S. (2022). Innovative Technology and Operations for Alleviating Poverty through Women's Economic Empowerment. *Production and Operations Management*, 31(1), 32–45. https://doi.org/10.1111/poms.13349

Tarlue, M. (2019, June 9). *Stop Progaganda Against 1V1D – Gov't Warns NDC.* Daily Guide Network. https://dailyguidenetwork.com/stop-propaganda-against-1v1d-govt-warns-ndc/

Tirivangasi, H. M. (2018). Regional disaster risk management strategies for food security : probing Southern African Development Community channels for influencing national policy. *Jamba*, 10(1), 1–7. https://doi.org/10.4102/jamba.v10i1.468

Tófoli, R. M., Dias, R. M., Zaia Alves, G. H., Hoeinghaus, D. J., Gomes, L. C., Baumgartner, M. T., & Agostinho, A. A. (2017). Gold at what cost? Another megaproject threatens biodiversity in the Amazon. *Perspectives in Ecology and Conservation*, 15(2), 129–131. https://doi.org/10.1016/j.pecon.2017.06.003

Tucker Lima, J. M., Valle, D., Moretto, E. M., Pulice, S. M. P., Zuca, N. L., Roquetti, D. R., Beduschi, L. E. C., Praia, A. S., Okamoto, C. P. F., da Silva Carvalhaes, V. L., Branco, E. A., Barbezani, B., Labandera, E., Timpe, K., & Kaplan, D. (2016). A social-ecological database to advance research on

infrastructure development impacts in the Brazilian Amazon. *Scientific Data*, 3(1), 160071–160071. https://doi.org/10.1038/sdata.2016.71

United Nations Convention to Combat Desertification. (n.d.). *Great Green Wall Initiative.* https://www.unccd.int/our-work/ggwi

United Nations Department of Economic and Social Affairs. (2015). *Sustainable Development*. https://sustainabledevelopment.un.org/sdgs

Ulloa, A. (2020). Environment and Development: Reflections from Latin America1. In Perreault, T., Bridge, G., & McCarthy J., (Eds.), *The Routledge handbook of political ecology* (pp. 320-331). Routledge.

Uphoff, N. (1993). Grassroots organizations and NGOs in rural development: Opportunities with diminishing states and expanding markets. *World Development*, 21(4), 607–622. https://doi.org/10.1016/0305-750X(93)90113-N

Van der Geest, K. (2011). North-South Migration in Ghana: What Role for the Environment? *International Migration*. 49(S1).

Vitousek, P. M., Mooney, H. A., Lubchenco, J., & Melillo, J. M. (1997). Human domination of Earth's ecosystems. *Science*, 277(5325), 494-499.

Watts, M. J. (2020). Now and then: the origins of political ecology and the rebirth of adaptation as a form of thought. In Perreault, T., Bridge, G., & McCarthy J., (Eds.), *The Routledge handbook of political ecology* (pp. 19-50). Routledge.

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2009). Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development*, 29(4), 503–515. https://doi.org/10.1051/agro/2009004

Wisner, B. (2020). Speaking truth to power: a personal account of activist political ecology. In T. Perreault, G. Bridge, & J. McCarthy (Eds.), *The Routledge Handbook of Political Ecology* (pp. 75–85). Routledge. https://doi.org/10.4324/9781315759289-13

World Meteorological Organization. (2017). *WMO guidelines on the calculation of climate normals*.

Yaro, J. A., & Hesselberg, J. (Eds.). (2016). *Adaptation to climate change and variability in rural West Africa*. Springer International Publishing.

Zaidi, A. (1999). NGO failure and the need to bring back the state. *Journal of International Development*, 11(2), 259–271. https://doi.org/10.1002/(SICI)1099-1328(199903/04)11:23.0.CO;2-N

Ziervogel, G., Bharwani, S., & Downing, T. E. (2006). Adapting to climate variability: Pumpkins, people and policy. *Natural Resources Forum*, 30(4), 294–305. https://doi.org/10.1111/j.1477-8947.2006.00121.x

Zimmerer, K. & Bassett, T. J. (2003). *Political ecology : an integrative approach to geography and environment-development studies*. Guilford Press.

APPENDIX

Individual or Group Interview Guide (*Field Formatted*)

I am a student from the United States studying the social and environmental impacts of your local dam. I am interested in learning how the dam has changed farming, the environment, and how the dam has impacted your community.

I want to chat with you because you live (and farm) here and would know if any changes have happened since the dam has been built.

I only want to show you the most respect. To protect your privacy and have your consent:

- I will not share any of your personal information with anyone.
- I will hide your name, where you live, or anything that can identify you.
- May I use a voice recorder and take notes? I want to make sure I understand you very well.
- You can choose to not answer any question or stop the interview at any time.

Do you want to participate? Do you have any questions before we begin?

My Research Questions:

1. How do local community members understand and use the newly constructed dam?
2. What are the social and environmental effects linked to the dam and how is the dam impacting nearby farming practices?

****

Farming and Livelihood:

1. Tell us what it is like to live here, in this community. How long have you lived here?
2. What do you do for a living?
    a. If farmer:
        i. Tell us about your farm.
        ii. Which crops do you grow?
        iii. What type of farming practices do you do?
        iv. What do you do with the food that you grow?
    b. If not farmer:
        i. What do you do for a livelihood?

Climate:

3. How have the rainy and dry season changed in recent years? Has this impacted your life in any way?

Dam Construction and Development: We hear that this community was part of the 1V1D project.

4. How did they build the dam? Why do you think it was built?
5. Why did they build it in this location?

Community Dam Use:

6. Who is using the dam, and how are they using it?
7. When does the dam have water, and how long does it last?
8. What do people use the dam for aside from irrigation?

Personal Use of the Dam:

9. How do you use the dam?
10. How has the dam changed your life, or the way you farm [if a farmer]?
11. How has the dam changed how and where you get water?

Environmental Change Related to Dam:

12. How has the environment changed since the dam was built?
13. Have there been health impacts from the dam?

Mining

14. Can you tell us more about galamsey and how it impacts the dam and your community?

Migration:

15. We hear that one of the objectives of 1V1D was that dams might help stop migration.
    a. What impact has the dam had on migration?

Basic demographics:

16. Would you be willing to share your age and ethnic group?

DO YOU HAVE ANY FINAL COMMENTS OR QUESTIONS FOR ME?

<u>Additional Notes</u>

State Official Interview Guide (*Field Formatted*)

I am a student from the United States studying the social and environmental impacts of the dam in Savannah as part of the One Village, One Dam initiative (1V1D). I am interested in learning more about how the dam has changed farming practices, the local environment, and how the dam has impacted the community. With permission, I am doing interviews with community members, making observations in and around the community, and want to know more about the local environment.

I want to chat with you because you are a State official and I want to understand the local government's involvement in this project, its goals, and the implementation (decision to build,

involvement with community, construction, etc.). I also want to understand your view of the One Village, One Dam initiative as a representative of this community at your particular government level (local, regional, federal) and as part of this project.

I want to be respectful of your time and privacy. To protect your privacy and have your consent:

- I will not share any of your personal information with anyone.
- I will hide your name, where you live, your title, or anything that can identify you unless you allow us to make the information from this interview public.
- May I use a voice recorder and take notes? I want to make sure that I understand you very well so that I do not misrepresent you.
- You can choose to not answer any question or stop the interview at any time.

Do you want to participate? Do you have any questions before we begin?

My Research Questions:

1. How do local community members understand and use the newly constructed dam?
2. What are the social and environmental effects linked to the dam and how is the dam impacting nearby farming practices?

****

Interview Questions

1. What are your responsibilities in this position? What does your job entail?
2. What do you know about the 1V1D and its goals? Are you noticing differences in your communities?
3. Can you tell us about 1V1D, including its objectives and successes so far?
4. Where does the State decide to build dams? How are they constructed, and why?
    a. Was there any community involvement in these decisions or the construction?
5. What challenges has 1V1D encountered?
6. How are dams impacting farming and land-use?
7. What are the plans for 1V1D moving forward?
8. Are there any water or agricultural concerns or illnesses that are changing in recent years?
9. What can you tell us about galamsey and how it impacts communities and the dam in Savannah?
10. What types of training or outreach is provided to farmers for their crops or animals?

DO YOU HAVE ANY FINAL COMMENTS OR QUESTIONS FOR ME?

Additional Notes: