

Dowd-Uribe, B.; Sanon, M.; Roncoli, C. and Orlove, B. 2018.  
Grounding the nexus: Examining the integration of small-scale irrigators  
into a national food security programme in Burkina Faso.  
Water Alternatives 11(2): 375-393



---

# Grounding the Nexus: Examining the Integration of Small-Scale Irrigators into a National Food Security Programme in Burkina Faso

**Brian Dowd-Uribe**

International Studies Department, University of San Francisco, San Francisco, CA, USA; [bdowduribe@usfca.edu](mailto:bdowduribe@usfca.edu)

**Moussa Sanon**

Institut de l'Environnement et de Recherches Agricoles, Gestion des Ressources Naturelles, Ouagadougou, Burkina Faso; [moussanonw@gmail.com](mailto:moussanonw@gmail.com)

**Carla Roncoli**

Department of Anthropology, Emory University, Atlanta, GA, USA; [carla.roncoli@emory.edu](mailto:carla.roncoli@emory.edu)

**Ben Orlove**

School of International and Public Affairs, Columbia University, New York, NY, USA; [bs05@columbia.edu](mailto:bs05@columbia.edu)

---

**ABSTRACT:** The water-food nexus literature examines the synergies and trade-offs of resource use but is dominated by large-scale analyses that do not sufficiently engage the local dimensions of resource management. The research presented here addresses this gap with a local-scale analysis of integrated water and food management in Burkina Faso. Specifically, we analyse the implementation of a national food security campaign (*Opération Bondofa*) to boost maize production in a subbasin that exhibits two important trends in Africa: a large increase in small-scale irrigators and the decentralisation of water management. As surface water levels dropped in the region, entities at different scales asserted increased control over water allocation, exposing the contested nature of new decentralised institutions, and powerful actors' preference for local control. These scalar power struggles intersected with a lack of knowledge of small-scale irrigators' cultural practices to produce an implementation and water allocation schedule that did not match small-scale irrigator needs, resulting in low initial enthusiasm for the project. Increased attention from national governments to strengthen decentralised water management committees and spur greater knowledge of, and engagement with, small-scale irrigators can result in improved programme design to better incorporate small-scale irrigators into national food security campaigns.

**KEYWORDS:** Water-food nexus, small-scale irrigators, food security, decentralisation, irrigation, Burkina Faso

---

## INTRODUCTION

In 2012, Burkina Faso experienced its most severe food security crisis in over a decade. Low rainfall during the 2011 rainy season resulted in significant production declines in three principal grain crops, maize (-5%), sorghum (-24%) and millet (-28%) (FAOSTAT, 2017); it left an estimated 2.85 million Burkinabè – 17% of its total population – food insecure (IFRC, 2012). To address the crisis, the Burkina

Faso government launched an unprecedented attempt to harness the agricultural potential of irrigated areas in the southern and western parts of the country. The campaign, known as *Opération Bondofa*<sup>1</sup> (which means "filling the granaries" in *Jula*, a regional *lingua franca*), provided improved maize seeds, fertilisers and tractor services to voluntarily enrolled farmers with the promise of a guaranteed purchase price, and continued for two subsequent dry-season campaigns. The immediate goal of the 2012 programme was to replenish the stocks of the national food security redistribution system operated by the *Société Nationale de Gestion des Stocks de Sécurité Alimentaire* (SONAGESS) that had been depleted by efforts to supply drought-affected parts of the country. In addition, the government intended to expand those stocks from a baseline of 35,000 to 150,000 tonnes (Kabore and Zoumbara, 2014) to enable the distribution of subsidised maize to food insecure households throughout the country. This plan also aimed to garner political support at a time when the long-term rule of President Blaise Compaoré was being increasingly challenged by political opposition and urban unrest.

Critical to the success of *Opération Bondofa* was a new class of farmers who until this time had received little national attention – small-scale irrigators who grow dry-season crops using diesel-powered pumps. Though underappreciated by many in the agricultural sector, the emergence of small-scale irrigators in Burkina Faso and many other parts of sub-Saharan Africa has led some informed observers to call their growing importance an 'irrigation revolution' (Dessalegn and Merrey, 2015). Experts now estimate that small-scale irrigation schemes cover more area than larger-scale schemes throughout large parts of sub-Saharan Africa (Dittoh et al., 2013; de Fraiture and Giordano, 2014). Burkina Faso's most recent irrigation census confirms this trend; it shows that small-scale irrigation less than 20 hectares (ha) in size is the largest irrigation group, covering 30,000 ha, almost triple that of large-scale irrigation schemes<sup>2</sup> (Abrić et al., 2011). Another key difference is that small-scale irrigators principally grow vegetables, contrary to their large-scheme counterparts, who principally produce grains (Dittoh et al., 2013). *Opération Bondofa* targeted small-scale irrigators since there were now the largest single group of irrigators with the most potential to produce dry-season maize.

*Opération Bondofa's* targeting of small-scale irrigators to produce dry-season maize fits into a broader shift in African nations seeking to boost national food security via domestic food production. The food-price hikes of 2007/08 have disproportionately affected African countries, many of which are dependent on rice imports from Asia (Moseley et al., 2010), and fomented significant protests against many ruling governments (Bush, 2010). One response to the food-price hikes and vulnerability to price fluctuations in the global market has been a renewed interest in producing more food domestically (Clapp, 2017). In Burkina Faso, the food price hikes were a catalyst for a broader social movement targeting 'la vie chère' – or the high cost of living. This movement organised general strikes throughout the country ultimately gaining key concessions from the government, including the establishment of subsidised food shops (Engels, 2015). *Opération Bondofa* fills a key role in this political context; it signals to political opponents a proactive effort to boost domestic grain production to meet national food security goals.

The incorporation of small-scale irrigators into national food security plans comes at a time of significant change and challenges in African water sectors. A majority of African nations, including Burkina Faso, are undergoing a restructuring of their water sectors. In most cases, these changes have brought about a decentralisation of water management (GWP, 2006; AMCOW, 2012). Burkina Faso adopted an ambitious Integrated Water Resources Management (IWRM) reform programme that

<sup>1</sup> First launched on November 4, 2011, *Opération Bondofa* was a national programme that targeted irrigated areas, which are primarily located in the western and southern parts of the country. The programme dedicated FCFA 2 billion to produce 50,000 tons of off-season maize (MAHRH, 2012).

<sup>2</sup> These data lumps smallholder private irrigation as well as community-managed irrigation together. It is widely believed that geographically dispersed smallholder private irrigators make up a significant portion of this total.

established hydrological basins as the organisational nexus for water management, and created new decentralised governance committees to serve as the chief arenas for local water decision-making (Petit and Baron, 2009; Cherlet and Venot, 2013). These new and evolving governance structures must not only attend to demands for a more equitable and sustainable water management, but also negotiate a number of developing challenges. New uses and users must be integrated into water allocation plans (Roncoli et al., 2016). Water storage and distribution infrastructures are deteriorating (Foster and Briceño-Garmendia, 2010). Rainfall is decreasing and/or falling at greater periodicity and intensity due to human-induced climatic change, reducing water availability while further straining water infrastructures (Bates et al., 2008; Roudier et al., 2011; Giannini et al., 2013). It is crucial to understand how the inclusion of small-scale irrigators to meet national food security goals in Africa interacts with new decentralised water governance institutions, and local agricultural production characteristics. We examine *Opération Bondofa* in Burkina Faso as one such case, which enables us to better understand the practical challenges to the integration of water and food management. A parallel goal is to demonstrate what a locally grounded analysis can contribute to a water-food nexus literature dominated by studies at larger scales of analysis. Our study addresses the following questions: How does the decentralisation of water management intersect with the national goal of ensuring food security via domestic sources? How is the allocation of water affected under such circumstances? How do dispersed, vegetable-growing small-scale irrigators, who are generally neglected by government ministries, respond to national campaigns to grow grains? What does this case say about the challenges to integrated resource management at the water-food nexus?

The article is structured as follows. First, we briefly review the water-food nexus literature and highlight two main gaps, the lack of local-scale analyses that examine the local dimensions of resource management, and the related lack of engagement with the broader resource management literature. We draw from this broader literature to situate the tensions and challenges that may emerge when small-scale irrigators become integrated into national food security programmes in Africa. We outline the research methods and situate the Upper Comoé subbasin study site before analysing *Opération Bondofa* with particular attention to governance struggles and disjunctures between the timeline of the campaign and the agricultural calendars of small-scale irrigators. We end with a discussion of the implications of our findings for the management of water and food resources and the broader water-food nexus literature.

## **WATER-FOOD NEXUS: WHERE'S THE LOCAL?**

The water-food nexus<sup>3</sup> has emerged as a new concept to characterise the interconnectivity of resource management (WEFWI, 2012). Originally proposed in the wake of food and financial crises in the first part of the 21st century, the nexus draws particular attention to how the management and allocation of water affects energy and food security. Since its first usage, the nexus concept has been developed by a suite of actors into different frameworks (Walker et al., 2014; Rasul and Sharma, 2016), and policy interventions (Scott et al., 2011; Bartos and Chester, 2014), and is being used in the development and monitoring of the UN Sustainable Development Goals (Biggs et al., 2015).

The growing nexus literature and its focus on the synergies and trade-offs of resource management has recently become the subject of a number of critiques. Foremost among them is the assertion that the nexus concept and literature underexplores the politics of resources management while foregrounding technological solutions (Allouche et al., 2015; Cairns and Krzywoszynska, 2016), which serves to further marginalise the poorest and most insecure (Leese and Meisch, 2015). Moreover, some

---

<sup>3</sup> The energy component of the nexus has been the topic of a growing literature (notably in Asia), including a special issue in *Water Alternatives* (Volume 8, Issue 1).

argue that a discussion of the interconnectivity of different resources is nothing fundamentally new (Wichelns, 2017), particularly given the substantial literature that explores parallel concepts and movements, including integrated water resources management (Van der Zaag, 2005; Benson et al., 2015), water security (Grey and Sadoff, 2007; Cook and Bakker, 2012) and adaptive governance (Pahl-Wostl, 2007; Scholz and Stiftel, 2010; Pahl-Wostl et al., 2012). Critics assert that the nexus literature fails to integrate findings from these and other literatures that interrogate the politics of resources management (Scoones, 2016; Hagemann and Kirschke, 2017).

Related to the lack of integration of parallel literatures is the emphasis of the nexus literature on larger scales of analysis. In general, the nexus literature is composed of contributions focused on the security aspects of water resources management (e.g. Wegerich et al., 2015), and systems approaches to the integration of resources into joint management schemes (e.g. Jalilov et al., 2015). Both groups of analyses concentrate principally on regional, national or basin scales (Rasul, 2014; de Strasser et al., 2015). While these studies bring useful conclusions, a greater engagement with local-scale analyses can bring needed and complementary findings (Biggs et al., 2015).

An engagement with parallel literatures and a need for more local-scale analyses are particularly important in relation to small-scale irrigation and decentralised water management. In general, the nexus literature has not substantively engaged with how these emerging trends affect the integration of water and food management, nor how they might affect national food security. For example, major contributions to the nexus literature often do not differentiate between large and small-scale irrigation projects (e.g. Bazilian et al., 2011). Many also fail to interrogate the movement towards decentralised water management, and how it may affect the goal of greater resource use efficiency (e.g. Hoff, 2011). A likely cause of these omissions is the geographic emphasis of the nexus literature outside of Africa, where the emergence of these trends is particularly pronounced. It is also likely a result of the nature of large-scale analyses, which must abstract across broad areas and phenomena. Nonetheless, the lack of attention is important to note, and we argue, can lead to findings that do not match local realities in places where these trends are important.

Our aim is to draw from the broader resource management literature to inform a local-scale analysis of the water-food nexus in Burkina Faso. More specifically, we focus our review on how the mobilisation of small-scale irrigators for the purposes of achieving national food security affects the management of water and food resources in the Upper Comoé subbasin.

### **SITUATING SMALL-SCALE IRRIGATORS IN NATIONAL FOOD SECURITY PROGRAMMES**

National food security programmes in Africa have changed considerably over the last 40 years. Prior to the 1980s, most nations explicitly focused on producing sufficient food domestically to feed their population. At this time, large-scale, as opposed to small-scale, irrigation schemes dominated dry-season agricultural production. Agricultural ministries played a large role in the management of such schemes, coordinating water releases, management and the diffusion of agricultural knowledge through extension services. Achieving greater domestic food production required the management of a handful of large-scale irrigation projects. Critical to this management were the centralisation of authority and the coordination of water releases with planting schedules. If these perimeters could be managed well – and this was a perennial challenge – thousands of producers could be mobilised to attend to national food security goals.

Structural adjustment and the rise of neoliberalism ruptured the linkage between domestic food production and national food security; global trade and social protections became the new methods to fill domestic food availability gaps (Devereux, 2016). Dry-season irrigation in general became less important to meeting domestic food security goals. But the food-price hikes of 2007/08 exposed the social risks of a dependence on imported foods, particularly in parts of food import-dependent Africa, resulting in a shift of focus back to food self-sufficiency (Clapp, 2017).

The contemporary shift in policy towards national food self-sufficiency means that national leaders are looking again to domestic producers to fill food availability gaps, with *Opération Bondofa* in Burkina Faso as one such example. Long-term approaches may mitigate some food insecurity crises. But without wholesale changes in productivity, most food insecurity crises are likely to be seasonal in nature and related to reductions in rainfall or other weather-related phenomena. Seasonal food insecurity allows for planned responses, but requires the collection and delivery of food at particular times. Seasonal food insecurity in Africa occurs most commonly at the outset of the rainy season, when food stocks are at their lowest (Burney, 2014). In countries with favourable rainfall and areas with different agricultural production seasons, governments can fill seasonal food deficits in one region or area, with production surpluses from another. However, many areas, such as Sahelian Africa, do not have that option since distinct rainy and dry seasons are shared across national territories, leaving few domestic choices to address seasonal food insecurity (de Graaff et al., 2011). In these regions, a viable way to do so is to rely on irrigated dry-season production.

The return to domestic and dry-season food production to meet national food self-sufficiency corresponds with a rise in the prominence of small-scale irrigation, raising a host of issues. The most prominent issue is allocation; in areas where small-scale irrigators draw from scarce surface water sources, water managers will need to make sufficient water available at appropriate times for irrigators to meet production goals. But features of small-scale irrigators complicate these efforts. Small-scale irrigators are prone to upstream-downstream dynamics in water use, what Lebel et al. (2005) call, the 'politics of position'; in times of water shortages, upstream users get to use water first, leaving downstream users at their mercy. The expansive geographic areas they farm can also mean that water releases may take longer to reach those farmers further from release points. This is further complicated given the high diversity of cultural practices among small-scale irrigators, and the particular seasonality to growing decisions. Small-scale irrigators sow according to a number of factors unique to each farming household and location, including market demands, land availability, agro-climatic conditions and the coordination of labour, among others. This results in a suite of different crops being grown, at different times, each with particular water needs and harvest schedules. The particular sowing decisions of small-scale irrigators can complicate water release schedules and enrolment in programmes with programmed sowing and harvest dates.

The water allocation issues raised above intersect with significant changes in water governance institutions on the continent. With the ascendance of IWRM as a global paradigm (Orlove and Caton, 2010) focusing attention on the appropriate scale for water governance (Woodhouse et al., 2017) national governments have been pressured to both rescale governance up to transboundary river institutions, and down, to local and watershed-based councils. These shifts in the scale of governance are related to the physical attributes of water – how it connects to particular geographic boundaries, otherwise known as watersheds or basins, and how it flows through and beyond political jurisdictions. Within nations, water governance has increasingly been rescaled down from the national scale and up from the local scale to the watershed (Cohen and Davidson, 2011). This has been criticised since the choice of what to include in watersheds is problematic, and new governance authorities often do not match the political dimensions of decision-making. This has led some to call for a centring of governance on the problemshed, which may be composed of areas and entities at different scales than the watershed (Moore and Willey 1991; Mollinga et al., 2007). Notwithstanding these debates, the establishment of new water governance regimes at different scales raises questions regarding whether they will better address efficiency, equity and sustainability issues than the institutions they replaced.

In principle, the decentralisation of water governance may hold opportunities for the growing number of small-scale irrigators. The localisation of deliberative spaces could allow for a greater understanding of their needs, and forums to press their demands. However, a growing body of literature questions whether decentralised water governance achieves these goals (Blomquist and Schlager, 2005). In some cases decentralisation may not be the most appropriate way to deal with

issues related to water management, which may require interventions at larger or different scales (Warner, 2007). In cases where decentralisation efforts have proceeded, power is often retained at larger scales (Norman and Bakker, 2009), and justified by technical capacity deficiencies at lower scales (Taddei, 2011). When effective decentralisation does occur, locally powerful actors can 'capture' these institutions and reinforce their control (Selby, 2003; Sherwill et al., 2007), particularly in contexts of high social inequality (Faysse, 2006). Moreover, issues of language or technical capacity can render participatory deliberative spaces inaccessible to many actors (Merrey et al., 2009). In Burkina Faso, a growing literature on IWRM shows that these spaces rarely achieve their participatory ideals (Roncoli et al., 2016), and when marginalised groups are included, in one case it was "not enough for them to redress these [power] imbalances to their benefit" (Daré and Venot, 2017: 186).

Small-scale irrigation poses particular challenges for new decentralised water governance institutions. The 'spontaneous and anarchic spread' of small-scale irrigators makes it difficult to assess the total number of users, or anticipate their water use patterns and specific needs (de Fraiture and Giordano, 2014: 171). This presents specific challenges for decentralised institutions, which often suffer from information and human resource limitations. The high spatial diffusion of small-scale irrigators can result in water-related conflicts that are difficult to predict or mitigate, again straining new institutions with limited resources. Agricultural ministries may be of little help to new decentralised institutions since they often overlook small-scale irrigators and can lack expertise in the novel agricultural and environmental issues that intensive riparian production entails.

Enrolling small-scale farmers in national food security programmes raises a host of issues, particularly under contexts of newly decentralised water management. Sufficient water allocations must reach geographically dispersed irrigators at appropriate times in order to meet production goals. This could lead to tensions in control over water allocations, since decentralised institutions may not always include effective representation of small-scale irrigators nor share the same goals as central-level ministries. Moreover, government authorities may attempt to supersede the jurisdiction of decentralised institutions in pursuit of national-level food security goals, which may result in destabilising those local decision-making bodies.

## RESEARCH METHODS AND STUDY SITE

### Research methods

This research draws from the significant understanding of environmental governance gained by team members over the course of earlier research projects at the study site since 2007 (Roncoli et al., 2009; Etkin et al., 2013). The research presented in this article draws directly from a project examining water governance in the Upper Comoé (Orlove et al., 2015; Roncoli et al., 2016). While conducting fieldwork in January 2012, the research team became interested in the dynamics surrounding *Opération Bondofa*. This article draws in particular from three research activities: (1) qualitative interviews with 160 stakeholders in the subbasin conducted from January 2012 – August 2013, (2) participant observations of water governance meetings during times of acute water shortages in January and February 2012, (3) a GPS survey of small-scale irrigators conducted in July-August 2012, and (4) an additional random survey of 60 riparian households along the Comoé and Yannon rivers conducted in July 2015. The initial interviews were conducted with local water governance committee members, local elected officials, civil-society representatives, agricultural extension agents, farmers, fisherfolk, pastoralists, and other relevant actors. Interview questions dealt principally with how water decisions are made in the context of a newly established participatory water governance structure. The goal of the GPS survey was to assess the extent of dry-season small-scale irrigation in the subbasin; the data gathered were shared with regional managers to improve water allocation planning. The household survey was conducted with a random sample of ten farmers in each of the six primary riparian villages in the subbasin.

(Lemouroudougou, Tiékouna, Sitiéna, Tengréla, Karfiguéla, Siniéna). Survey questions focused on the productive, livelihood and environmental implications of dry season agriculture. All interactions occurred in French, or in one of two local languages, *Jula*, or *Fulfulde* (the latter being the language of Peul pastoralists), with the aid of local research assistants.

### Study site: The Upper Comoé subbasin

The Upper Comoé subbasin is located in the Cascade Region of southwestern Burkina Faso, one of the wettest parts of the country, receiving an average annual rainfall of 1,100 mm (Roncoli et al., 2009). The climate is characterised by one rainy season, spanning from May to October, with most precipitation falling between June and September. A number of rain-fed food crops, such as maize, millet, sorghum, groundnut, cowpea and rice – as well as cotton – are produced during this period. Due to its relatively abundant rainfall the region has become known as the breadbasket of the country. This climatic advantage, along with existing water storage infrastructure, and one of few permanent rivers in Burkina Faso – the Comoé – is transforming it into a zone of substantial dry-season production.

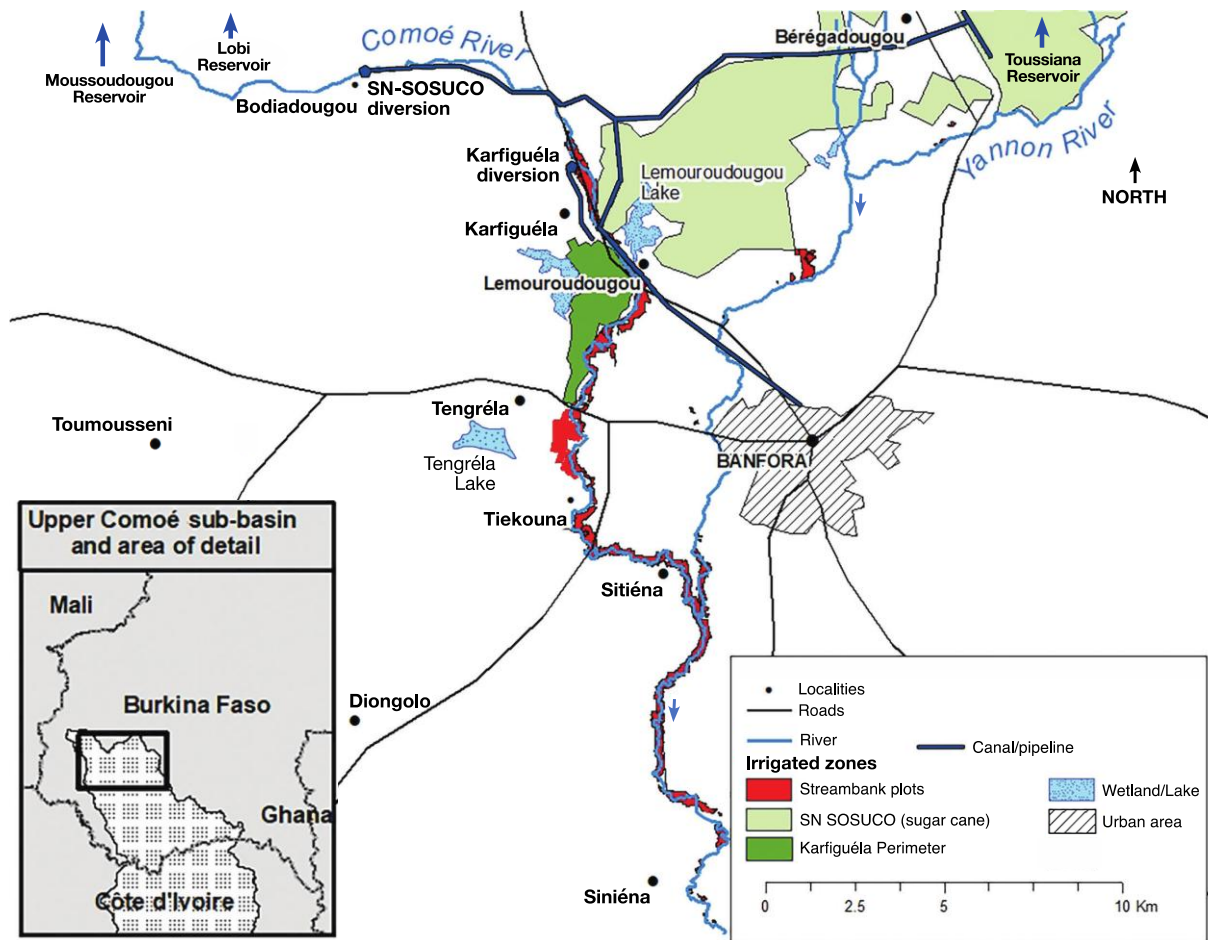
The Comoé River originates in southwestern Burkina Faso, crossing the border with Cote d'Ivoire to flow into the Gulf of Guinea. The Burkina Faso portion comprises about 18% of the total basin and includes the Upper Comoé and its main tributary, the Yannon. Water from these two rivers is captured into three reservoirs, known as the Lobi (6 million m<sup>3</sup>) and Moussoudougou (38 million m<sup>3</sup>) Reservoirs on the Comoé, and the Toussiana (6 million m<sup>3</sup>) Reservoir on the Yannon, built in 1976, 1991, and 1982, respectively. These reservoirs and the system of canals and pipes comprise a water management system that provides water to a number of stakeholders. They include (1) a sugar company, *La Nouvelle Société Sucrière de la Comoé*, (SN-SOSUCO), (2) *L'Office National de l'Eau et de l'Assainissement* (ONEA), a water utility that supplies potable water to the urban centre of Banfora, the administrative capital of the region, (3) a downstream 350-ha irrigated perimeter located adjacent to Karfiguéla Village and cultivated by several local farmers' cooperatives, (4) a fluctuating number of dry-season small-scale irrigators along the Comoé and the Yannon, who are loosely organised by village into local irrigation committees, (5) settled and transient pastoralists, and (6) artisanal fisherfolk. There is considerable overlap between water user categories, so that the same farmers may cultivate a plot in the Karfiguéla perimeter as well as along the riverbanks, while also keeping livestock or engaging in fishing (Roncoli et al., 2016).

## WATER RESOURCE MANAGEMENT IN THE UPPER COMOÉ SUBBASIN

### Water governance

The creation of SOSUCO (renamed SN-SOSUCO in 1998) in 1960 involved the appropriation of land where local communities lived and of wetlands and fields where they practised agriculture. In 1970, the Government of Burkina Faso with Chinese and Taiwanese funding constructed the Karfiguéla irrigated perimeter to partly compensate for displacing these community members. Initially, SOSUCO relied on pumped water from Lemouroudougou Lake and other local water bodies to irrigate its fields. As those began to dry out and sugar cane plantations expanded, the reservoirs were established to provide water for irrigation, setting in motion changes that continue to impact local agriculture and water management. The dams – especially the much larger Moussoudougou Reservoir which captured the waters of the Upper Comoé River – significantly altered regional hydrology affecting seasonal flooding and flows, wetland use, fishing practices, and livestock movements. The reduced streamflow in the Comoé downstream of Moussoudougou meant that river water was no longer sufficient to irrigate all 350 ha in the Karfiguéla perimeter. Consequently, Karfiguéla farmers organised an alternating irrigation schedule according to which one half of the perimeter receives water during one dry season and the other half gets it the following year, a rotation that is still practised today.

Figure 1. The Upper Comoé subbasin in southwestern Burkina Faso, 2013 (adapted from Cour 2010).



The construction of the reservoirs on the Comoé River set perimeter farmers and SOSUCO in direct competition over the same water resource (Roncoli et al., 2009). This tension was further aggravated and complicated by the emergence of small-scale diesel pump irrigated agriculture in the mid-2000s. Suddenly, a new group of actors began to use the same water resources, albeit principally downstream from both the major pipes servicing the sugar cane fields and the Karfiguéla perimeter. Nonetheless, their claims to, and use of, river water led to an increasingly tense setting culminating in protests in 2007 over access to water resources (Orlove et al., 2015).

As this backdrop of water-related conflicts unfolded, the Government of Burkina Faso embarked on an ambitious reform of its national water governance in line with the global movement toward integrated water resources management (IWRM). The formal governance of water resources in the region changed with the adoption of Burkina Faso's 2003 action plan for the adoption and implementation of IWRM, or *Plan pour la Gestion Intégrée des Ressources en Eau*, known as PAGIRE. This built on earlier water law reforms in 1998 and 2001, which moved the country towards greater participation and integration (MAHRH, 2006).<sup>4</sup> The Cascades Region and the Upper Comoé subbasin in particular were identified as a site for early IWRM implementation given its history of tension over water resource use (Tioro, 2007).

<sup>4</sup> For a detailed chronology of IWRM reforms in Burkina Faso see Cherlet and Venot (2013) and Petit and Baron (2009).



The centrepiece of the new policy is the establishment of local water user committees in micro-watersheds throughout the country. The committee in the Upper Comoé (*Comité Local de l'Eau de la Haute Comoé*, or CLE-HC) was established in 2008 and constitutes the main vehicle for user participation in water governance. Basin-level authorities (or *Agences de L'Eau*) are expected to serve as a further site of basin-level deliberations and provides technical and administrative assistance to the CLEs. The *Agence* for the Comoé basin was officially established in 2013, but it was not fully operational until 2015.

The CLE-HC is composed of a general assembly and a small executive committee. The general assembly is a large body comprising regional and provincial directors of relevant ministries (agriculture, water, infrastructure, etc), mayors of the five communes within the CLE-HC boundaries, and representatives of local civil society organisations and user groups (Sally et al., 2011). The small executive committee is the main operational organ of the CLE-HC and comprises 14 CLE-HC members, including representatives from SN-SOSUCO, ONEA, regional mayors' offices and civil society organisations. Notably absent from the small executive committee are representatives of important water users including small-scale irrigators, pastoralists and fisherfolk.

The executive committee is charged with the creation of an annual water allocation plan, and manages the CLE-HCs activities as approved by the general assembly. This allocation plan, which is developed during the beginning of each dry season (sometime between November and January) when farmers prepare to irrigate their fields, estimates water needs of the three major water uses – SN-SOSUCO, the Karfiguéla perimeter, and small-scale irrigators. It also includes a quota for ONEA and a provision for a minimum flow to sustain riparian ecosystems (Roncoli et al., 2009). Allocations are sequenced according to how needs vary over time. For example, the Karfiguéla perimeter does not receive water until January/February when irrigated dry-season production begins.

### Small-scale irrigation

The steep increase in small-scale irrigation in the Upper Comoé began with the African Development Bank-funded *Projet d'Appui au Développement Local dans la Comoé, Léraba, et Kenedougou* (PADL – CLK), which subsidised the purchase of water pumps from 2004 to 2012. The PADL-CLK project distributed motorised water pumps at 10% of total cost financing the diffusion of 632 diesel-powered water pumps in the Upper Comoé subbasin and an adjacent subbasin. With pump costs on average of 250,000 CFA<sup>5</sup> (USD540)<sup>6</sup> in 2009 (Abric et al., 2011), many small-scale irrigators are now able to purchase new pumps, or upgrade older pumps, without donor or government assistance.

Our GPS measurements confirm the significant impact the introduction of these pumps has had on the extent of small-scale irrigation. Local extension agents estimate that prior to the introduction of motorised pumps, dry-season riparian agriculture covered only about 30 ha over the entire subbasin, with only one cropping cycle occurring during the dry season (Dowd-Urbe et al., 2012). By 2013, the area cultivated along the riverbanks had increased to 660 ha. Most of this area now supports three cropping cycles spanning the dry and early rainy seasons.

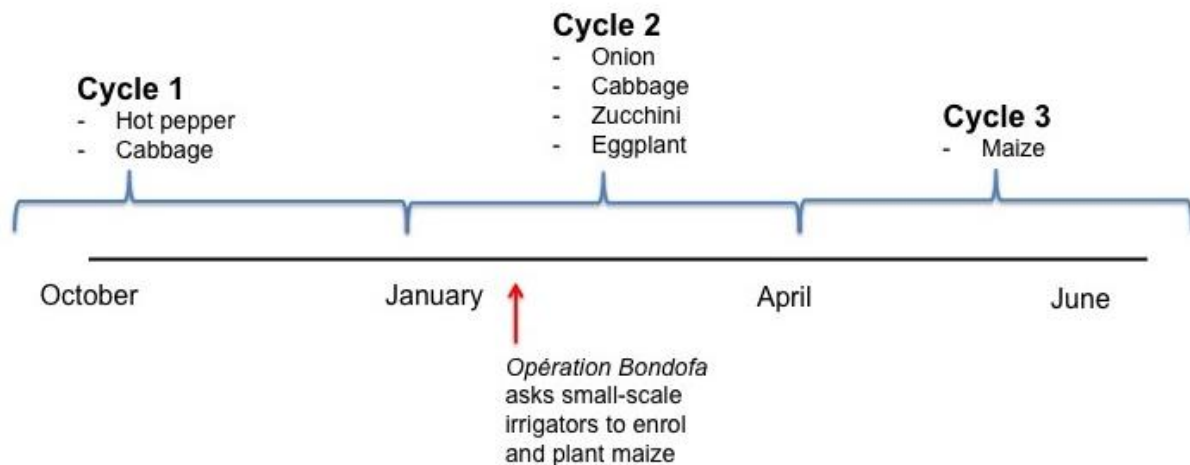
Almost all small-scale irrigators interviewed in 2015 reported cultivating three distinct cycles (see Figure 2). The first cycle begins in September/October just as the rains begin to subside, with most farmers planting hot pepper or cabbage. Most farmers begin growing second cycle vegetable crops in January, the most common of which are onion, cabbage, zucchini and eggplant. These are preferred

<sup>5</sup> Pump prices ranged from 40,000 FCFA (US\$86) to 1,000,000 FCFA (US\$2158) depending on pump characteristics. Pumps ranged from a maximum outflow of 18 m<sup>3</sup> per hour to 58 m<sup>3</sup> per hour.

<sup>6</sup> Based on xe.com currency conversion for 1 July 2009.

due to the prevailing growing conditions and market demand, and are destined for consumption throughout Burkina Faso and neighbouring Cote d'Ivoire.

Figure 2. Small-scale irrigator agricultural cycles in the Upper Comoé subbasin, and main crops grown in each cycle (Source: Authors' survey and interviews).



A third cycle begins at the very end of the dry season, with almost all farmers planting a rapidly maturing variety of maize. Farmers begin this last cycle irrigating their maize crop, and then, as the rain begins to fall more consistently in July, allow the rains to finish watering the crop. Farmers time their planting to ensure that maize is harvested before August, the rainiest month of the year, to avoid damage from waterlogging. This early maize crop permits farmers to take advantage of the seasonal price increase for maize, since cereal crops grown in rain-fed upland fields are not ready for harvest until September/October. This last point is elaborated below in the discussion of *Opération Bondofa*.

### OPÉRATION BONDOFA

*Opération Bondofa* fuelled contestation over water resources and confronted implementation challenges in its goal to voluntarily enrol small-scale irrigators in the Upper Comoé to grow dry season maize. We examine below the governance struggles that developed related to water allocations of unusually scarce water resources. We also examine the mismatch between *Bondofa* planting dates, water release schedules, and the agricultural calendars of small-scale irrigators.

### Governance struggles

The political importance of the *Bondofa* campaign and the relatively low levels of water in the region led to significant contestation over water-allocation decisions with different actors vying for control over negotiations. Issues with water availability were particularly acute in the 2011/12 dry season in the Upper Comoé, not only due to the rise of small-scale irrigators, but also due to infrastructural issues; the Moussoudougou Dam, the largest in the systems of three dams, suffered from fissures, restricting water storage to 30% of its total capacity. At the same time, President Blaise Compaoré's beleaguered regime was eager to score political points in the run-up to a highly contentious parliamentary election to be held in December 2012. The *Bondofa* campaign was a means to address citizens' concerns, responding to food insecurity in the North while stimulating agricultural productivity in the South. Water allocations that reached *Bondofa* farmers were essential to the success of the programme.

Against this backdrop, and just as in previous years, the CLE-HC executive committee met to create its annual water allocation plan. Negotiations, however, soon broke down given the low level of stored water in the three main reservoirs, and the lack of an easy plan that met the needs of major stakeholders, most notably, SN-SOSUCO. Given the importance of water allocations to the success of the *Bondofa* campaign, however, the Ministry of Agriculture directed its Provincial Directorate to restart negotiations, in what was an attempt by the ministry formerly in charge of water for irrigation (i.e. Ministry of Agriculture) to recentralise authority despite the establishment of new decentralised water governance institutions (i.e. CLE-HC). In the words of one CLE-HC executive committee member:

We decided not to do a water release programme this year because the dam had problems. But because of the *maize Bondofa*, we were required to do it. The Minister [of Agriculture] charged the *Agence de L'Eau* to make a water release programme so that the farmers could grow maize (Interview #37).

Since the *Agence de l'Eau* was not operational, local agricultural officials convened a meeting to resurrect negotiations, side-stepping the CLE-HC. Many of the same stakeholders present in CLE-HC meetings gathered, but expressed displeasure that the Ministry of Agriculture was the convener of such a meeting. Notable among these dissenters was SN-SOSUCO and an important local politician – the President of the Regional Council. The latter might have seen his authority undermined by the Minister's intervention.

These locally powerful actors successfully insisted that water allocation negotiations once again come under the purview of the new decentralised authority, the CLE-HC. New negotiations hatched a modified plan that asked for the deficits in water to be equally shared among the three major water users – SN-SOSUCO, Karfiguéla, and small-scale irrigators. This plan also failed to be fully enacted, however, leaving local water users at the mercy of water releases controlled by SN-SOSUCO. As water became scarcer, and small-scale irrigators in downstream villages complained about a shortage of water, a new meeting organised by the Ministry of Agriculture took place, again outside the purview of the CLE-HC. Ultimately this meeting also failed to reach a consensual water allocation plan, or a roadmap to attain one.

Most small-scale irrigators were never aware of the attempts of the Ministry of Agriculture to assert its authority and re-centralise water allocation decisions. Nor were they aware of SN-SOSUCO's effective control over water releases given the failure of decentralised authorities to achieve a consensual allocation plan. Irrespective of this lack of knowledge, many local farmers expressed strong confidence that whatever the issues with water availability, or wherever the venue for water allocation decisions, water would be available for their crops. The reason for such confidence was their understanding of the political salience of the *Bondofa* campaign.

Prior to the onset of water shortages, interviews with farmers demonstrated their confidence that the political importance of the *Bondofa* campaign would result in sufficient water allocations to meet their needs. One small-scale irrigator commented on January 22, 2012, "Because the [local ministry of agriculture] encourages maize cultivation, and because their agents come to the village all the time, if they see there isn't water they tell SOSUCO directly to release water" (Interview #35). A different small-scale irrigator echoed these comments in an interview on January 27, 2012, "It is because of maize this year that the [ministry of agriculture] pushes SOSUCO to allow water to pass. It is also because of the Karfiguéla plain. It's not because of [small-scale irrigators] that they push to make water pass this way" (Interview #52).

This confidence was soon challenged, though, as water shortages became more pronounced, leading to conflicts between downstream and upstream water users, and later with SN-SOSUCO. Conflicts were particularly pronounced between small-scale irrigators in the downstream villages of Sitiéna and Tiékouna, and Karfiguéla farmers further upstream. Small-scale irrigators from Sitiéna coordinated to take apart a makeshift sandbag dam erected by a large water user. They also arranged a 24-hour watch

at the upstream sluice gates, which directed water to the Karfiguéla plain, to ensure that they remained opened allowing water to flow downstream.

Ultimately, small-scale irrigators from all downstream villages organised a march on local government offices in the regional capital of Banfora. As this proposed march was communicated to key officials, it quickly became apparent that it could embarrass the national government at the time of a politically important food security campaign. This dynamic led to the intervention of the Minister of Agriculture from the capital city, Ouagadougou, who requested an exceptional release of water from SN-SOSUCO, effectively ending the crisis (Orlove et al., 2015).

### Mismatched timescales

As the iterative struggle over water allocations unfolded, the *Bondofa* campaign endured other challenges related to the timing and scope of the programme. Though small-scale irrigators expressed confidence in the prospect of having sufficient water for their crops, most small-scale irrigators in the Upper Comoé showed little initial enthusiasm for the *Bondofa* programme. One major reason for this lack of enthusiasm was the mismatch of the campaign with established farming practices.

The *Bondofa* campaign targeted small-scale irrigators at a time in their agricultural calendar when most had substantially invested in crops that were already established (see Figure 2). Officials of the Ministry of Agriculture asked small-scale irrigators to plant maize in late January and early February, when most had already planned and sowed a vegetable crop for the second dry-season cycle. Though these officials offered substantial incentives to entice irrigators to plant maize, it did not make sense for many growers; it would have required pulling out crops and planting maize resulting in a significant loss of capital. Some small-scale irrigators did enrol in the *Bondofa* campaign, though the area devoted to maize was comparatively small. In early February – when most of the *Bondofa* maize should have already been planted – interviews with agricultural officials confirmed that less than 1/3 of the projected goal of 1800 ha for the greater region had been sown.

This programmatic mismatch is likely a result of a general lack of understanding of and engagement with, small-scale irrigators, and a ministry still tied to the logic of large-scale irrigated perimeters. Local agricultural extension agents and affiliates of the local ministry of agriculture are accustomed to working with large-scale irrigation schemes like the Karfiguéla perimeter to coordinate water releases and planting date schedules. In this case, *Opération Bondofa* was planned around the Karfiguéla perimeter's normal planting schedule; water would be released towards the end of January and beginning of February. Maize sowing would be coordinated to ensure that water was available according to the physiological needs of the plant. Officials of the Ministry of Agriculture attempted to do the same with small-scale irrigators, visiting riparian villages asking irrigators to plant their maize crops at the same time. The coordination of planting dates, however, proved very difficult to organise. Small-scale irrigators are geographically dispersed along approximately 15 kilometres of riverbanks on two separate rivers, the Comoé and Yannon. The preparation and planting of these plots takes several weeks, and happens according to the complex labour demands of the household, among other variables. Although some local agricultural officials had knowledge of small-scale irrigation sowing calendars, pressure to enrol farmers superseded considerations of how best to meet small-scale irrigators cultural practices.

Small-scale irrigators were interested in growing maize, but in the third dry-season cycle. Third cycle maize is commonly practised, with sowing occurring in April/May, and harvesting in July/August. Second-cycle vegetable production plays an important role in third cycle maize production; revenue generated from the sale of vegetable crops is used to purchase needed inputs. Apparently, the maize grown in the third cycle did not match the desired programmatic and implementation dates for *Opération Bondofa*, which sought high enrolment numbers in January and February to communicate them to superiors eager to show progress towards meeting dry-season production goals.

## DISCUSSION: INTEGRATING WATER AND FOOD MANAGEMENT

The *Bondofa* campaign reveals the local-level complexities when small-scale irrigators are targeted for a national food security campaign. One key theme considered here are the scalar dynamics of water governance. Burkina Faso is a regional model in its implementation of decentralised water governance, and the Upper Comoé is one of Burkina Faso's most advanced cases. Nonetheless, the Ministry of Agriculture overrode the mandate of the decentralised water governance committee, the CLE-HC, and attempted to craft a water allocation schedule that would deliver water to dry-season maize growers. The government officials wanted to ensure that farmers received sufficient water allocations to meet national production goals. The power struggle that ensued left SN-SOSUCO in effective control of water infrastructure and allocations, and the Ministry of Agriculture struggling to regain control. Ultimately, it succeeded by negotiating with SN-SOSUCO to release an emergency water allocation, but only after downstream irrigators went without irrigation water for several weeks.

Water governance is always political (Mollinga et al., 2007; Houdret et al., 2014), but this case provides particular insights into the outcomes of political contestations when the integrated management of water and food becomes a national and local imperative. Here, the contestation process reveals the tensions between decentralisation reforms and the desire of centralised authorities to assert power at critical moments, exposing the contingent nature of water governance institutions. The iterative power tussle that ensued illustrates that the transfer of power to new decentralised governance does not begin and end with their establishment, and transcends concerns about the extent of power devolution (Larson and Soto, 2008). The consolidation of authority is also not necessarily a gradual process, where each year more power is devolved and greater institutionalisation occurs. Rather, this case shows that the establishment of decentralised governance structures and the devolution of power are continually contested, and crises can initiate struggles, which, temporarily or permanently, lead to a restructuring of decision-making authority.

The *Bondofa* case also revealed structural issues that undermine the effectiveness of the new decentralised water governance institutions. Despite the establishment of the CLE-HC, the sugar cane company still retained effective control over water storage and delivery infrastructure via a previous agreement with the central government. Prior to low water levels in 2011/12, this arrangement did not present any issues. SN-SOSUCO collaborated with stakeholders in CLE-HC deliberations to construct a consensual water allocation plan. It made little difference which entity opened the gates to release water, so long as the releases respected the agreement. But the water crisis, and the focus on water allocations for the *Bondofa* campaign, revealed SN-SOSUCO's continued effective control over key water infrastructures. When its role was arguably most important, the CLE-HC's inability to affect actual water allocations and deliveries essentially validated the imposition of the Ministry of Agriculture to create water allocation plans. It remains to be seen whether the establishment of the *Agence de l'Eau* will facilitate the transfer in control over these infrastructures, and clarify the roles of different entities. But even if the *Agence de l'Eau* had been fully established and clarified the authority over water allocation infrastructures, the CLE-HC may not have been able to successfully steward the water crisis and meet the water allocation demands of the *Bondofa* campaign. Locally powerful actors like SN-SOSUCO can still disproportionately influence water allocation decisions brokered by decentralised water governance institutions (Warner, 2007). Nonetheless, decentralised water governance institutions like the CLE-HC cannot endeavour to reach their potential as sites for consensual water allocations decisions without greater intervention from the central government to clarify and enforce power relations (Brown, 2013).

*Opération Bondofa* exposed a contradiction: small-scale irrigators are growing in importance to local economies and national food security programmes, yet are neglected by agricultural and water institutions and are generally not well understood. The clearest example of this lack of understanding is in the temporal dimensions of the *Bondofa* programme. The desire for a coordinated planting date

demonstrated a disregard for the diversity of circumstances influencing the planting schedules of farming households along long stretches of two different rivers. Moreover, the programme reflected an alignment with historic water release schedules for the Karfiguéla perimeter, not the seasonal calendars of small-scale irrigators. Perhaps officials of the Ministry of Agriculture were simply acting on orders from their superiors, and reached out to small-scale irrigators in haste to quickly boost enrolment numbers. But regardless of motivations, the roll out of the programme represented a mismatch with the cultural practices of small-scale irrigation. These disconnects echo the conclusions of previous research (e.g. de Fraiture and Giordano, 2014), which notes the difficulties of government agencies to assess, incorporate and service the needs of small-scale irrigators.

Nonetheless, small-scale irrigators were ultimately able to successfully influence water allocations in their favour. Small-scale irrigators are essentially shut out of formal water decision-making, and demonstrate limited knowledge of governance sites and procedures. Nonetheless, small-scale irrigators successfully organised to influence key decision-makers to intervene on their behalf. Small-scale irrigators understood the political importance of the *Bondofa* campaign and its likely effect on water availability. As one prominent local leader noted, the *Bondofa* campaign became "the means to resolve the problem [of water shortages] quickly". As small-scale irrigators organised for more water, two contradictions emerged. The retention of effective power at the national-level – rather than the full devolution of power to new decentralised committee CLE-HC – allowed small-scale irrigators to influence water allocation decisions in their favour. This contradicts one of the often-cited reasons to implement decentralised management: to promote greater local control and equity. Meanwhile a campaign few small-scale irrigators fully embraced became a way to leverage power to meet their livelihood goals – to produce vegetables *not Bondofa* maize.

## CONCLUSION: A GROUNDED NEXUS

The nexus literature brings needed attention to the synergies and trade-offs associated with resource use. Most nexus research, however, uses high scales of analysis obscuring the local dimensions associated with their management. The grounded analysis presented here draws from the broader resource management literature and reveals important challenges to the integrated management of water and food resources in Burkina Faso and other areas in Africa where small-scale irrigators are becoming the norm and government officials increasingly looking to them as critical to the success of national food security programmes. Research that examines these complexities does not muddy the waters of policy formation and implementation. Rather it can reveal management synergies different to, but complementary of, larger-scale analyses.

Our analysis of the *Bondofa* campaign in Burkina Faso shows how decentralised institutions are contingent spaces of governance; crises reveal their contested nature while exposing the political and structural challenges to their authority. In some cases greater intervention from centralised authorities can clarify power relations, enforce decentralisation mandates, and mitigate capture by locally powerful actors. These findings draw from and extend key conclusions from the broader resources management literature. They also have important implications for the nexus literature. Tensions between decentralised institutions, centralised authorities and locally powerful actors can complicate efforts to promote greater resource use synergies and to meet policy goals. More attention to the logics feeding these tensions is needed to inform efforts to improve efficiencies.

Strains in governance are compounded by the increase in small-scale irrigation throughout Africa. Small-scale irrigators continue to grow in size and importance, but a lack of basic information about their cultural practices, water use patterns, and extent complicate efforts to include them in water allocation plans. Traditional ministries have devoted few resources to improve these knowledge deficiencies, or to service their particular needs. This lack of attention has complicated efforts to enrol them in national food security campaigns. As this case shows, greater understanding of small-scale

irrigator needs and cultural practices can inform and improve food security programme design in innovative ways. In addition, a focus on small-scale irrigators can reveal how – despite being shut out of formal decentralised governance institutions – they can effectively navigate the political terrain to address their needs for greater access to water resources. In both regards, the nexus literature would benefit from greater attention to their voices.

What is clear from this example is that small-scale irrigators are interested in growing maize when it makes sense for them. In fact, the production of vegetables can be seen as a key piece in greater total maize production – it finances the purchase of inputs needed to achieve high yields. Moreover, small-scale irrigators repeatedly mentioned the lack of government support not only for vegetable production, but also for their rainy season maize crops. Herein lies an opportunity where increased government awareness and support of the needs of small-scale irrigators can play a role in boosting maize production in general, and for dry-season campaigns in particular. Small-scale irrigators may be more likely to enrol in a dry-season national food security campaign like *Bondofa*, provided enough incentives are offered (e.g. fertilizer and diesel subsidies) and the timing of the programme is aligned to their agricultural calendar. This could happen in one of two ways: (1) reaching out to irrigators earlier in the year to influence second-cycle planning decisions, and (2) modelling the programme after their agricultural calendars by promoting an early third cycle planting and swift transport to food-insecure areas. Beyond these interventions, a secure credit mechanism for rainy-season maize production would decrease the need to grow high-value but labour-intensive and risky vegetables, allowing for greater interest in dry-season maize production while boosting overall maize production.

These micro policy recommendations hold important lessons for the water-food nexus literature that endeavours to improve the synergies of resource use. While larger-scale analyses can point to the greater movements and uses of resources across basins or national territories, they rarely interrogate or unpack how local-level dynamics affect such resource allocations. Importantly, they can miss how a directive, say, to address national food insecurity, may not reach its full potential due to mismatches and incongruence with the interests and priorities of key stakeholder groups. This analysis reveals the potential of local-level studies to yield complementary findings, supporting the call for greater linkages between local and large-scale analyses in the nexus literature.

## ACKNOWLEDGMENTS

Funding for the research was provided by the National Science Foundation's Decision-Making Under Uncertainty programme through a cooperative agreement with the Center for Research on Environmental Decisions (NSF SES-0951516). The authors are grateful to the farmers and the stakeholders who participated in interviews and to their research assistant, Hamadou Issa Diallo, for their important contribution to the study. They thank Drs. Colin Thor West and Elizabeth Kago Nebié for producing the map and Kristin Tanis for the graphic work. Constructive and insightful comments of three anonymous reviewers significantly improved the original manuscript.

## REFERENCES

- Abric, S.; Sonou, M.; Augéard, B.; Onimus, F.; Durlin, D.; Soumaila, A. and Gadelle, F. 2011. *Lessons learned in the development of smallholder private irrigation for high-value crops in West Africa*. Washington, DC: The World Bank.
- AMCOW (African Ministers' Council on Water). 2012. *Status report on the application of integrated approaches to water resources management in Africa*. [www.amcow-online.org/images/docs/2012%20africa%20status%20report%20on%20iwrmpdf](http://www.amcow-online.org/images/docs/2012%20africa%20status%20report%20on%20iwrmpdf) (accessed 17 February 2017)
- Allouche, J.; Middleton, C. and Gyawali, D. 2015. Technical veil, hidden politics: Interrogating the power linkages behind the nexus. *Water Alternatives* 8(1): 610-626.

- Bartos, M.D. and Chester, M.V. 2014. The conservation nexus: Valuing interdependent water and energy savings in Arizona. *Environmental Science & Technology* 48(4): 2139-2149.
- Bates, B.; Kundzewicz, Z.W.; Wu, S. and Palutikof, J. 2008. *Climate change and water*. Geneva: Intergovernmental Panel on Climate Change.
- Bazilian, M.; Rogner, H.; Howells, M.; Hermann, S.; Arent, D.; Gielen, D.; Steduto, P.; Mueller, A.; Komor P.; Tol, R. and Yumkella, K.K. 2011. Considering the energy, water and food nexus: Towards an integrated modelling approach. *Energy Policy* 39(12): 7896-7906.
- Benson, D.; Gain, A. and Rouillard, J. 2015. Water governance in a comparative perspective: From IWRM to a 'nexus' approach? *Water Alternatives* 8(1): 756-773.
- Biggs, E.M.; Bruce, E.; Boruff, B.; Duncan, J.M.; Horsley, J.; Pauli, N.; McNeill, K.; Neef, A.; Van Ogtrop, F.; Curnow, J. and Haworth, B. 2015. Sustainable development and the water-energy-food nexus: A perspective on livelihoods. *Environmental Science & Policy* 54: 389-397.
- Blomquist, W. and Schlager, E. 2005. Political pitfalls of integrated watershed management. *Society and Natural Resources* 18(2): 101-117.
- Brown, J. 2013. Can participation change the geography of water? Lessons from South Africa. *Annals of the Association of American Geographers* 103(2): 271-279.
- Burney, J.A. 2014. Creating synergies between water, energy, and food security for smallholders. In Naylor, R.L. (Ed), *The evolving sphere of food security*. New York: Oxford University Press.
- Bush, R. 2010. Food riots: Poverty, power and protest. *Journal of Agrarian Change* 10(1): 119-129.
- Cairns, R. and Krzywoszyńska, A. 2016. Anatomy of a buzzword: The emergence of 'the water-energy-food nexus' in UK natural resource debates. *Environmental Science & Policy* 64: 164-170.
- Cherlet, J. and Venot, J.P. 2013. Structure and agency: Understanding water policy changes in West Africa. *Water Policy* 15(3): 479-495.
- Clapp, J. 2017. Food self-sufficiency: Making sense of it, and when it makes sense. *Food Policy* 66: 88-96.
- Cohen, A. and Davidson, S. 2011. The watershed approach: Challenges, antecedents, and the transition from technical tool to governance unit. *Water Alternatives* 4(1): 1-14.
- Cook, C. and Bakker, K. 2012. Water security: Debating an emerging paradigm. *Global Environmental Change* 22(1): 94-102.
- Cour, J. 2010. Water management of the upper Comoé River Basin, Burkina Faso. West Africa Irrigation Project (WAIPRO). Ouagadougou, Burkina Faso: International Water Management Institute.
- de Fraiture, C. and Giordano, M. 2014. Small private irrigation: A thriving but overlooked sector. *Agricultural Water Management* 131: 167-174.
- de Graaff, J.; Kessler, A. and Nibbering, J.W. 2011. Agriculture and food security in selected countries in sub-Saharan Africa: Diversity in trends and opportunities. *Food Security* 3(2): 195-213.
- Dessalegn, M. and Merrey, D.J. 2015. Motor pump revolution in Ethiopia: Promises at a crossroads. *Water Alternatives* 8(2): 237-257.
- de Strasser, L.; Lipponen, A.; Howells, M.; Stec, S. and Bréthaut, C. 2016. A methodology to assess the water energy food ecosystems nexus in transboundary river basins. *Water* 8(2): 59.
- Devereux, S. 2016. Social protection for enhanced food security in sub-Saharan Africa. *Food Policy* 60: 52-62.
- Dittoh, S.; Bhattarai, M. and Akuriba, M.A. 2013. Micro irrigation-based vegetable farming for income, employment and food security in West Africa. In Hanjra, M.A. (Ed), *Global food security: Emerging issues and economic implications*, pp. 177-200. New York: Nova Science Publishers.
- Dowd-Urbe, B.; Roncoli, C. and Orlove, B. 2012. Water grows food: Dry season farming, food sovereignty, and integrated water resource management in Burkina Faso. *Association of Concerned Africa Scholars*, Bulletin No. 88.
- Engels, B. 2015. Contentious politics of scale: The global food price crisis and local protest in Burkina Faso. *Social Movement Studies* 14(2): 180-194.



- Etkin, D.; Kirshen, P.; Watkins, D.; Roncoli, C.; Sanon, M.; Some, L.; Dembele, D.; Sanfo, J.; Zoungrana, J. and Hoogenboom, G. 2013. Stochastic programming for improved multiuse reservoir operation in Burkina Faso, West Africa. *Journal of Water Resources Planning and Management* 141(3): 04014056.
- FAOSTAT. 2017. *Maize, sorghum and millet production statistics for Burkina Faso*. [www.fao.org/faostat/en/#data/QC](http://www.fao.org/faostat/en/#data/QC) (accessed 10 January 2016)
- Faysse, N. 2006. Troubles on the way: An analysis of the challenges faced by multi-stakeholder platforms. *Natural Resources Forum* 30(3): 219-229.
- Foster, V. and Briceño-Garmendia, C. 2010. *Africa's infrastructure: A time for transformation*. Washington, DC: The World Bank.
- Giannini, A.; Salack, S.; Lodoun, T.; Ali, A.; Gaye, A.T. and Ndiaye, O. 2013. A unifying view of climate change in the Sahel linking intra-seasonal, interannual and longer time scales. *Environmental Research Letters* 8(2): 024010.
- Grey, D. and Sadoff, C.W. 2007. Sink or swim? Water security for growth and development. *Water Policy* 9(6): 545-571.
- GWP (Global Water Partnership) 2006. *Setting the stage for growth*. Stockholm: Global Water Partnership.
- Hagemann, N. and Kirschke, S. 2017. Key issues of interdisciplinary NEXUS governance analyses: Lessons learned from research on integrated water resources management. *Resources* 6(1): 9, [www.mdpi.com/2079-9276/6/1/9/html](http://www.mdpi.com/2079-9276/6/1/9/html)
- Hoff, H. 2011. *Understanding the nexus. Background paper for the Bonn 2011 conference: The water, energy and food security nexus*. Stockholm: Stockholm Environment Institute.
- Houdret, A.; Dombrowsky, I. and Horlemann, L. 2014. The institutionalization of river basin management as politics of scale – Insights from Mongolia. *Journal of Hydrology* 519: 2392-2404.
- IFRC (International Federation of the Red Cross and Red Crescent Societies). 2012. *Emergency appeal: Burkina Faso food insecurity*. Dakar: International Federation of the Red Cross and Red Crescent Societies.
- Jalilov, S.M.; Varis, O. and Keskinen, M. 2015. Sharing benefits in transboundary rivers: An experimental case study of Central Asian water-energy-agriculture nexus. *Water* 7(9): 4778-4805.
- Kabore, F. and C. Zoumbara. 2014. Sécurité alimentaire au Burkina Faso: Une stratégie de collecte des excédents céréaliers en gestation à la SONAGESS. *Sidwaya* 27 (August 2014). [news.aouaga.com/h/33200.html](http://news.aouaga.com/h/33200.html) (accessed 26 August 2017).
- Larson, A.M. and Soto, F. 2008. Decentralization of natural resource governance regimes. *Annual Review of Environment and Resources* 33: 213-239.
- Leese, M. and Meisch, S. 2015. Securitizing sustainability? Questioning the 'water, energy and food-security nexus'. *Water Alternatives* 8(1): 695-709.
- Lebel, L.; Garden, P. and Imamura, M. 2005. The politics of scale, position, and place in the governance of water resources in the Mekong region. *Ecology and Society* 10(2): 18.
- MAHRH (Ministère de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques). 2006. *Etat de mise en œuvre du plan d'action pour la gestion intégrée des ressources en eau (PAGIRE) du Burkina Faso*. Ouagadougou, Burkina Faso: Ministère de l'Agriculture, de l'Hydraulique et des Ressources, Halieutiques.
- Merrey, D.J.; Léville, H. and van Koppen, B. 2009. Are good intentions leading to good outcomes? Continuities in social, economic and hydro-political trajectories in the Olifants river basin, South Africa. In Molle, F. and Wester, P. (Eds), *River basin trajectories: Societies, environments and development*, pp. 47-74. Colombo, Sri Lanka: International Water Management Institute.
- Mollinga, P.P.; Meinzen-Dick, R.S. and Merrey, D.J. 2007. Politics, plurality and problems: A strategic approach for reform of agricultural water resources management. *Development Policy Review* 25(6): 699-719.
- Moore, D. and Willey, Z. 1991. Water in the American West: Institutional evolution and environmental restoration in the 21st Century. *University of Colorado Law Review* 62(4): 775-825.
- Moseley, W.G.; Carney, J. and Becker, L. 2010. Neoliberal policy, rural livelihoods, and urban food security in West Africa: A comparative study of The Gambia, Côte d'Ivoire, and Mali. *Proceedings of the National Academy of Sciences* 107(13): 5774-5779.

- Norman, E.S. and Bakker, K. 2009. Transgressing scales: Water governance across the Canada-US borderland. *Annals of the Association of American Geographers* 99(1): 99-117.
- Orlove, B. and Caton, S.C. 2010. Water sustainability: Anthropological approaches and prospects. *Annual Review of Anthropology* 39: 401-415.
- Orlove, B.; Roncoli, C. and Dowd-Urbe, B. 2015. Fluid entitlements: Constructing and contesting water allocations in Burkina Faso, West Africa. In Hastrup, K. and Hastrup, F. (Eds), *Waterworlds: Anthropology in fluid environments*, pp. 46-74. New York, NY: Berghann Books.
- Pahl-Wostl, C. 2007. Transitions towards adaptive management of water facing climate and global change. *Water Resources Management* 21(1): 49-62.
- Pahl-Wostl, C.; Lebel, L.; Knieper, C. and Nikitina, E. 2012. From applying panaceas to mastering complexity: Toward adaptive water governance in river basins. *Environmental Science & Policy* 23: 24-34.
- Petit, O. and Baron, C. 2009. Integrated water resources management: From general principles to its implementation by the state. The case of Burkina Faso. *Natural Resources Forum* 33(1): 49-59.
- Rasul, G. 2014. Food, water, and energy security in South Asia: A nexus perspective from the Hindu Kush Himalayan region. *Environmental Science & Policy* 39: 35-48.
- Rasul, G. and Sharma, B. 2016. The nexus approach to water-energy-food security: An option for adaptation to climate change. *Climate Policy* 16(6): 682-702.
- Roncoli, C.; Kirshen, P.; Etkin, D.; Sanon, M.; Somé, L.; Dembélé, Y.; Sanfo, B.J.; Zoungrana, J. and Hoogenboom, G. 2009. From management to negotiation: Technical and institutional innovations for integrated water resource management in the Upper Comoé River Basin, Burkina Faso. *Environmental Management* 44(4): 695-711.
- Roncoli, C.; Dowd-Urbe, B.; Orlove, B.; West, C.T. and Sanon, M. 2016. Who counts, what counts: Representation and accountability in water governance in the Upper Comoé sub-basin, Burkina Faso. *Natural Resources Forum* 40(1-2): 6-20.
- Roudier, P.; Sultan, B.; Quirion, P. and Berg, A. 2011. The impact of future climate change on West African crop yields: What does the recent literature say? *Global Environmental Change* 21(3): 1073-1083.
- Sally, H.; Léville, H. and Cour, J. 2011. Local water management of small reservoirs: Lessons from two case studies in Burkina Faso. *Water Alternatives* 4(3): 365-382.
- Scholz, J.T. and Stiftel, B. (Eds). 2010. *Adaptive governance and water conflict: New institutions for collaborative planning*. Washington, DC: Resources for the Future.
- Scoones, I. 2016. The politics of sustainability and development. *Annual Review of Environment and Resources* 41: 293-319.
- Scott, C.A.; Pierce, S.A.; Pasqualetti, M.J.; Jones, A.L.; Montz, B.E. and Hoover, J.H. 2011. Policy and institutional dimensions of the water-energy nexus. *Energy Policy* 39(10): 6622-6630.
- Selby, J. 2003. Dressing up domination as 'cooperation': The case of Israeli-Palestinian water relations. *Review of International Studies* 29(1): 121-138.
- Sherwill, T.; Arendse, L.; Rogers, K.; Sihlophe, N.; Van Wilgen, B.; van Wyk, E. and Zeka, S. 2007. Stakeholder connectedness and participatory water resource management in South Africa. *Water SA* 33(4): 505-511.
- Taddei, R. 2011. Watered-down democratization: Modernization versus social participation in water management in Northeast Brazil. *Agriculture and Human Values* 28(1): 109-121.
- Tioro, A. 2007. *Rapport d'étude sur l'identification et le ciblage des zones susceptibles de mise en place de Comités Locaux de l'Eau dans la zone du Programme VREO*. Ouagadougou: Programme de Valorisation des Ressources en Eau de l'Ouest (VREO).
- Van der Zaag, P. 2005. Integrated Water Resources Management: Relevant concept or irrelevant buzzword? A capacity building and research agenda for Southern Africa. *Physics and Chemistry of the Earth, Parts A/B/C* 30(11-16): 867-871.
- Walker, R.V.; Beck, M.B.; Hall, J.W.; Dawson, R.J. and Heidrich, O. 2014. The energy-water-food nexus: Strategic analysis of technologies for transforming the urban metabolism. *Journal of Environmental Management* 141: 104-115.
- Warner, J. (Ed). 2007. *Multi-stakeholder platforms for integrated water management*. Aldershot, UK: Ashgate.

- Wegerich, K.; Van Rooijen, D.; Soliev, I. and Mukhamedova, N. 2015. Water security in the Syr Darya basin. *Water* 7(9): 4657-4684.
- Wichelns, D. 2017. The water-energy-food nexus: Is the increasing attention warranted, from either a research or policy perspective? *Environmental Science & Policy* 69: 113-123.
- WEFWI (World Economic Forum Water Initiative) 2012. *Water security: The water-food-energy-climate nexus*. Washington, DC: Island Press.
- Woodhouse, P.; Veldwisch, G.J.; Venot, J.P.; Brockington, D.; Komakech, H. and Manjichi, Â. 2017. African farmer-led irrigation development: Re-framing agricultural policy and investment? *The Journal of Peasant Studies* 44(1): 213-233.

THIS ARTICLE IS DISTRIBUTED UNDER THE TERMS OF THE CREATIVE COMMONS *ATTRIBUTION-NONCOMMERCIAL-SHAREALIKE* LICENSE WHICH PERMITS ANY NON COMMERCIAL USE, DISTRIBUTION, AND REPRODUCTION IN ANY MEDIUM, PROVIDED THE ORIGINAL AUTHOR(S) AND SOURCE ARE CREDITED. SEE [HTTP://CREATIVECOMMONS.ORG/LICENSES/BY-NC-SA/3.0/LEGALCODE](http://creativecommons.org/licenses/by-nc-sa/3.0/legalcode)

