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## Scale as a Key Factor for Sustainable Water Management in Northwest Honduras

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### Cover Page Footnote

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## Scale as a Key Factor for Sustainable Water Management in Northwest Honduras



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### ABSTRACT

*In northwest Honduras, community-based interventions by outside development agencies seeking to assist communities with the treatment and delivery of potable water have been largely ineffective. This article examines the social, economic, ecological, and engineered contexts of gravity-fed water systems in the Palmarejo Valley of this region, identifying key barriers to long-term sustainability. Drawing from the results of our mixed-methods research in the valley, incorporating ethnographic and spatial analyses along with water quality testing, we outline the limitations of community-based development approaches that ignore the broader social and political scales of resource inequalities. We find that water provisioning often requires coordination of activities at broader sociospatial and sociopolitical scales, which implicate the involvement of multiple communities with competing interests, variable power, and divergent claims on resources. We argue that community-scaled approaches to intervention are unable to mitigate the pressures on water resources that emerge in and extend to other scales, because they cannot adequately recognize and attend to cross-scale dynamics. We propose that development planning agencies may find more sustainable solutions to water resource challenges if communities are recognized as historically changing networks of actors and institutions operating according to diverse motivations and desires.*

### INTRODUCTION

Sustainable water management (an organizational mode that preserves the renewability of the resource and equitable access to it) in less developed countries is fast becoming one of the greatest environmental challenges of the twenty-first century (UNICEF and WHO 2011). The United Nations Human Rights Council recently passed a global resolution (Resolution 64/292) declaring “safe and clean drinking water and sanitation” a basic human right (cf. Bakker 2007; Miroso and Harris 2011;

UN 2010), and calling on states and international agencies to supply financial resources, technology transfer, and capacity building to provide for safe and accessible water and sanitation. Meanwhile, in Honduras, government agencies charged with overseeing water and sanitation have largely failed to meet the demands of growing metropolitan areas (Balthasar 2011). Private sector participation in water and sanitation services in periurban regions of the country has also experienced significant challenges and setbacks (Phumpiu and Gustafsson 2009). Community-based interventions in rural sec-

tors by outside development organizations seeking to design treatment and delivery of potable water have also been largely ineffective (Fogelberg 2010). Even self-organized efforts by communities in different residential contexts have been unsustainable (Casey 2005). Why are communities in Honduras struggling to obtain safe and clean water?

In this article, we take a holistic look at the social, economic, ecological, and engineered contexts of gravity-fed water systems in the Palmarejo Valley, a predominantly rural sector in northwest Honduras, with the greater goal of identifying key barriers to long-term sustainability of water provisioning. In doing so, we apply a systems-based perspective employing a grounded-theory and mixed-methods approach to cultural analysis (e.g., Billgreen and Holmén 2008; Loker 2003; Wells et al. 2014), which allows us to view water management as a socioecological system (Bennett 1976) that couples human behaviors and perceptions with the biophysical environment. This perspective resembles what geographers and other social scientists increasingly refer to as the “hydrosocial cycle” (Linton 2014; Sultana and Loftus 2012; Swyngedouw 2009), which “attends to the social nature of [hydrological] flows as well as the agential role played by water, while highlighting the dialectical and relational processes through which water and society interrelate” (Linton and Budds 2013:1). After describing the household and community contexts of water management systems in Honduras, we present the results of our emerging work in the Palmarejo Valley, where we have conducted interviews with valley residents and community leaders, mapped cultural and environmental features using GPS, and performed water quality tests to measure levels and isolate sources of heavy metals and bacterial contamination.

We have observed that community-based approaches commonly employed in development projects in this region may not be appropriate in all contexts due, in part, to the scale at which they operate. While the utility of the concept of scale has been debated (Leitner and Miller 2007; Marston et al. 2005; Moore 2008), we find it useful in our research for character-

izing the sociospatial constructs that actors develop and deploy in different political and economic contexts to influence how individuals, organizations, and institutions manage resources (see Herod 2011; e.g., Goodman et al. 2008). Here, our emphasis is not on spatial categories, *per se*, but on the social processes that constitute them (Marston 2000) and the connections that link them (Latour 1993). The social construction of scale can thus be seen as a material expression of power relations (MacKinnon 2010). Water, in particular, is increasingly subject to “scale challenges” (Cash et al. 2006), because it moves across social and natural landscapes—or waterscapes (Budds and Hinojosa 2012)—that crosscut multiple scales (Norman et al. 2012). The Palmarejo case contributes to this literature by showing how the disconnections and fragmentations between the scales at which water is managed can create challenges for devising governance systems to deal with transboundary environmental phenomena (see Haarstad 2014).

In the Palmarejo Valley, outside non-governmental organizations (NGOs) have partnered with local communities, which are defined based on the residential proximity of households. To encourage locally driven development and aid in the implementation of local projects, NGOs have worked with families to establish community-based water user associations for managing water resources. However, our research reveals that the community scale, which is considered to be the primary unit of development intervention, is not a simple geographical construct but also has multiple sociospatial and sociopolitical meanings that shift among the different stakeholder groups involved. Local water perceptions and practices cross-cut household and community boundaries, are shaped by institutional arrangements at multiple scales, and are subject to structural inequities in access to resources. These scale challenges have often led to misunderstandings and miscommunications that leave the local water associations unable to mitigate the negative impacts of broader socioeconomic forces and that threaten the long-term sustainability of water management systems. As such, the community, as currently operationalized in development efforts, is a problematic scale for intervention.

## WATER AND DEVELOPMENT IN HONDURAS

The United Nations estimates that as many as 768 million people lack access to safe drinking water globally, and that more than one billion people (15 percent of the world's population) do not have access to basic sanitation facilities (UN 2013:47-49). Almost one million of them live in Honduras, predominantly in rural areas (UN 2005:191). In this country, the situation has seen only limited improvement in recent years. For example, between 1990 and 2011, only 13 percent of the total urban and rural population experienced improvements in drinking water sources (JMP 2013:21). Many of these developments are due, in part, to the adoption of a declaration by the General Assembly of the United Nations, committing to "time-bound and measurable goals for combating poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women" (UN 2002:1). Now referred to as the Millennium Development Goals (MDGs), these eight goals provide a framework, including targets and indicators of progress, for addressing some of the world's most pressing problems. Among the targets of Millennium Development Goal Number 7 (Ensure Environmental Sustainability), Target 10 aims to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation" (UN 2002:16-17).

To meet this target, various development agencies, NGOs, and other organizations around the world have directed significant efforts toward providing safe drinking water to some of the world's most-in-need populations. In Honduras, for example, the United States Agency for International Development worked with the National Autonomous Water and Sanitation Service of Honduras (SANAA) to introduce water and sanitation systems to 98 communities in 2006 (USAID 2006). Similar projects are being carried out by various non-governmental organizations, such as Water.org (water.org), The Resource Foundation (resourcefnd.org), and Engineers without Borders

(ewb-usa.org), among others. Recently, Water For People (waterforpeople.org) has pledged to help meet Millennium Development Goals: "Water For People will aggressively expand its programs to play an important role in meeting this goal" (Water For People 2007:2). As with many other non-governmental organizations, Water For People has also adopted the assessment tools (described below) by which this goal is evaluated.

The approaches employed by these water projects are similar on at least two points. First, responding to some of the problems of large-scale, top-down development approaches (Elyachar 2002), initiatives since the early 1990s have focused on community participation (Evans and Appleton 1993; Figueiredo and Perkins 2013; Madrigal et al. 2011; McCommon et al. 1990). In these approaches, households are viewed as the primary consumers, and are encouraged to inform the development and deployment of the system to fit their own needs. In addition, by better understanding the operation of the system and its capacities, households can maximize (in terms of efficiency and positive health outcomes) their engagement with it (Schouten and Moriarty 2003). Part of the rationale is that by involving stakeholders in the planning and implementation process, local communities will be more likely and able to maintain the system once external support is gone (von Korff et al. 2012).

The second similarity among current water projects is that the solution implemented to provide safe drinking water is most often technological (Lopez-Gunn and Llamas 2008; Wells et al. 2014). For example, Water For People-Honduras reports that it supports 15 to 20 communities each year, helping approximately 15,000 people obtain safe drinking water, sanitation services, and hygiene education (Water For People 2012). Typical projects include protected springs, gravity-fed water systems, pumped water systems, storage tanks, and pour-flush latrines (Cook et al. 2010). The emphasis on technology is heavily influenced by the targets and indicators of progress set by the Millennium Development Goals. "Access to drinking water means that the source is less than 1 km away from its place of



use and that it is possible to reliably obtain at least 20 liters per member of a household per day... Access to safe drinking water is the proportion of people using improved drinking water sources: household connection; public standpipe; borehole; protected dug well; protected spring; rainwater" (WHO 2012a). Thus, to reduce the number of people without "sustainable access to safe drinking water" implies the construction of water systems within 1 km of the target population, in addition to the protection of more distant spring sources where appropriate. The focus of water development is therefore located at the scale of the community where more people can be served with one engineered system and where local support is likely to be greatest.

However, concerns regarding the sustainability of community-based approaches or those focused on technological fixes have been raised (e.g., Agrawal 2005; Cooke and Kothari 2001; Humphries et al. 2000; Mansuri and Rao 2004; van de Meene et al. 2011). Mansuri and Rao (2004; see also Conning and Kevane 2002), for example, question the effectiveness of such projects to assist economically poor individuals without consideration of existing power imbalances internal and external to the target population (e.g., chapters in Sultana and Loftus 2012). Some community-based approaches have noted that technology-driven projects are less likely to be successful without the inclusion of initiatives aimed at building social capital (Brondizio et al. 2009; e.g., Humphries et al. 2000; Isham and Kahkonen 2002). In post-Hurricane Mitch disaster recovery projects in Honduras, for example, housing construction failed due to a lack of individuals' capacity to invest, access, and use resources embedded in social networks to maintain new homes (Barrios 2014).

Considerable literature has pointed out problems specifically with the concept of community in community-based development (e.g., Cleaver 2001:44-46; Leach et al. 1999; Mohan 2001:158-162), and it is useful to summarize those findings here. Cleaver (2001) and Mohan (2001), for instance, point out the tendency in development projects to treat communities as natural and harmonious social units in

which consensus is the norm, without recognizing internal variation in needs, desires, or worldviews—findings that echo Schwartz's (1978) classic critique of community development models in Latin America. Succinctly summarized by Israel and colleagues (1998:13) in reference to community-based public health programs in the U.S., the challenges and conflicts directly related to how community is defined include: "the extent to which a sense of community exists; who represents the community; the extent to which community participants are members of community-based organizations and/or more grass-roots groups and how they relate back to those organizations; who in the community is excluded; the extent to which participants from community-based organizations represent and reflect community members; and competition or turf issues between community-based organizations and community groups." For example, investigating the factors that influence the performance of drinking water systems in rural Honduras, Gelting and Ortolano (1998:214) identified motivation, capacity, access, local knowledge, and ongoing support from outside the community as key elements. As Schwartz (1978:256) astutely observed over 30 years ago, "local development is a complex interplay of community culture and external forces working through time." Thus, many issues and concerns regarding community-based approaches have been raised, all of which are relevant for pro-poor development in Honduras (Classen et al. 2008; Loker 2004; Phumpiu 2008).

Our investigation of the Palmarejo case adds to these concerns by questioning the appropriateness of the community as the social and spatial scale targeted for intervention and development. While community is a problematic term in general (cf. Anderson 1983; Cohen 1985; Delanty 2003; Murdock 1949; Redfield 1955), in Honduras "community" or **la comunidad** is a catch-all term used to refer to a small residential settlement, typically from a few families to one thousand or so people, as well as the social, political, and economic relations that constitute the group. Thus, while local-level approaches involving the legitimate participation of diverse stakeholders

is vital, based on the Palmarejo data we suggest that the water problems of many rural Honduran communities derive from broader structural issues that cannot be addressed fully by a single community and/or with technology (e.g., Brondo and Bown 2011; Loker 1998; Stonich 1993, 1998; Stonich et al. 1998; Tucker 2008). We therefore argue that scale—as a relational, sociospatial construct (Marston 2000)—is a key variable in the politics of provisioning reliable water to households. In the remainder of this article, we describe the current water situation in the Palmarejo Valley, which illustrates potential limitations of community-level interventions and technological solutions for combating forces that negatively impact water resources in the region.

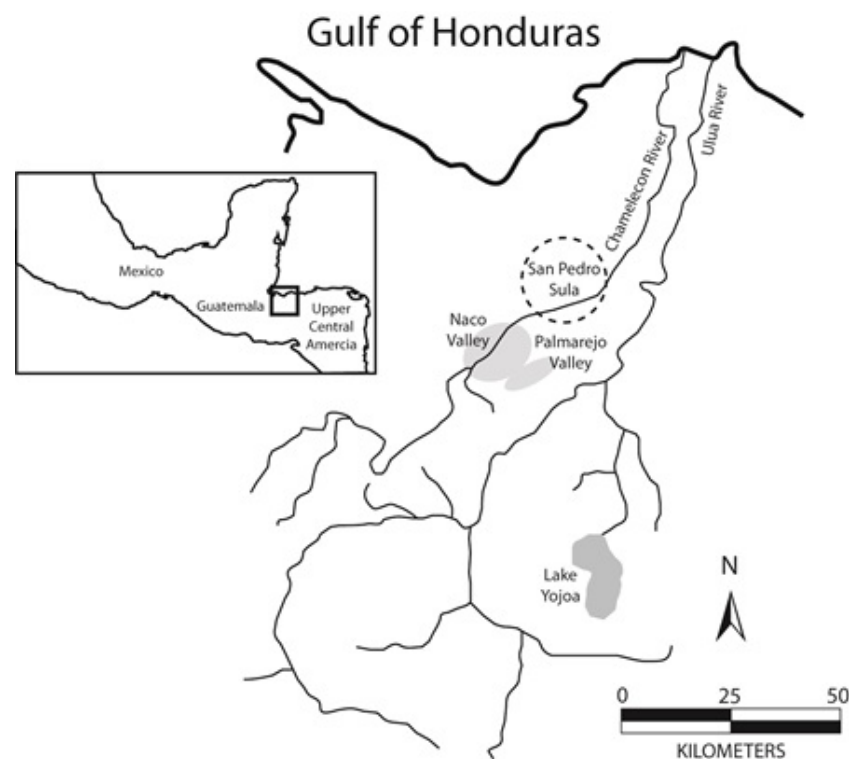
## THE PALMAREJO VALLEY

The Palmarejo Valley is a 10 km<sup>2</sup> pocket of the larger Naco Valley in northwestern Honduras (Figure 1).

Located just a few miles from the urban fringes of San Pedro Sula, Honduras's second largest and fastest growing commercial city, the region is surrounded by tall mountains of the Sierra de Omoa. Beginning in the early 1940s, families (mostly of indigenous Lenca ancestry) from the central highlands of Honduras arrived and settled the modern communities of Palmarejo and Palos Blancos. In the 1970s, when national agrarian land reforms granted plots of land to rural campesinos (Arriaga 1986), the region's population increased significantly, and settlements at Campo Nuevo, El Morro, and Suyapa were established adjacent to large haciendas to which village residents supplied labor. In the late 1980s, two small villages, Mango and Las Contreras, were founded by landless campesinos who settled on unoccupied spaces alongside roads on the western edge of the valley.

Our research focused on the oldest, and presently the smallest, communities in the valley, Palmarejo and Palos Blancos, which are situated less than 2

km apart. Palmarejo consists of 48 households encompassing a population of approximately two hundred people, ranging in age from new-born to 75 years. Most households were represented by nuclear families, although some were extended families and single-parent (women) families. Education levels varied among households, from no education to some primary school, only rarely past the third grade. Unemployment was high. Those who had jobs outside the home worked in local farming or cattle ranching industries or else in nearby clothing factories (*maquilas*), and earned an income from 600 to 2,400 lempiras (US\$30–\$120) per month. In a few cases, women operated small convenience stores, *pulperías*, from their home. Most



**FIGURE 1.** The location of the Palmarejo Valley in northwestern Honduras.

households owned their land and homes, and most had access to at least some electricity.

The community of Palos Blancos was much smaller at the time of our research, consisting of only 14 households and a population of 80 people, with residents' ages ranging from 2-75 years. Most households included extended kin (some have up to 15 people). Education, employment, and income levels matched those of Palmarejo, with the exception that a few households in Palos Blancos claimed to be entirely self-sufficient (e.g., smallholders).

Farming and cattle ranching are the two predominant industries impacting contemporary land and water use in the Palmarejo region. Cattle ranching is not extensive, but is becoming more pervasive as fertile soils in the region become exhausted from intensive agriculture (Wells et al. 2013). Farming is common among all of the communities throughout the area today, and farming ranges from small kitchen gardens to large commercial farms. Farmers with small plots often grow corn, beans, and squash, and continue to use swidden (slash-and-burn) agriculture and digging sticks to cultivate the land. There are at least four commercial farms in the region that use industrial tractors and other high-capital farm equipment: one producing **zacate** (grass) for cattle feed, another cultivating papaya, a third focused on watermelon production, and the fourth growing corn and sorghum. While most residents consider this region to be "rural," many are increasingly making a living in nearby San Pedro Sula as the city extends closer to the Palmarejo Valley every year. We suspect that in the near future, this region will become periurban, and thus subject to the complex kinds of competing practices and conflicts that often emerge in urbanizing zones over resource access and development (Ravetz et al. 2013; Seto et al. 2010).

Topographically, the valley is a small catchment at one time watered by eight seasonal streams called **quebradas**, which eventually drained into the large Chamelecón River of the adjacent Naco Valley. The quebradas meander downslope east to west, cutting cavernous gorges—up to 8 m deep in some areas—

into the alluvial terraces and fans that give shape to the modern landforms. Most occupation is restricted to within about 50 m of the quebradas' edges, leaving open vast tracts of land that receive around 1300 mm of rainfall each year (Andrade 1990). Presently, the flow of only one of those quebradas, Quebrada Grande on the southern edge of the valley, reaches the Chamelecón. The remainder have experienced a significant decrease in water flow, some to the point of complete desiccation, as large commercial farms and ranches siphon water for crops and cattle, and deforestation of the surrounding hillslopes and mountaintops advances unabated. These activities have had tremendous implications for the seven villages that occupy the Palmarejo Valley.

The Water Institutional Reform of 2002 sought to decentralize water management throughout the country—a process in line with the poverty reduction strategy for Honduras approved by the International Monetary Fund and the World Bank—thus shifting responsibilities for water and sanitation to local municipalities after decades of centralized administration (Phumpiu 2008). The result thus far in the Palmarejo region has been a lack of laws, policies, or regulations for water and wastewater. Instead, the organization of water management—that is, how each of the distribution systems is managed—varies throughout the valley. For some of the villages, the need to find new sources of water has led to the formation of village-based water user associations, called **juntas de agua**, which have worked in partnership with outside NGOs to design, build, and in most cases finance the new water systems. The water user associations operate independently of the federal and municipal governments and range from formal boards, with rotating elected positions of authority—in which case water use fees are collected from village residents (not everyone pays, however)—to informal, ad hoc committees that come together when needed, in which case no water fees are collected. Water user associations maintain the water system and regulate the distribution of water. Each water user association is responsible only for the water supply of the village in which its members live, even if the source is shared by multiple villages.



## METHODS

To begin to assess the impacts that local social and environmental changes have had on the water supplies of the valley, we conducted in-depth interviews with residents, mapped cultural and environmental features of the communities, and carried out water quality tests from 2004-2007 and in 2011. In 2004-2005, we carried out in-depth, semi-structured interviews with a past president of a water user association in one of the communities, the current treasurer of a water user association in another community, four residents of both villages, and seven residents of neighboring communities ( $n = 13$ ). In 2006, the same individuals from Palmarejo and Palos Blancos were re-interviewed, in addition to the former president of a now-defunct water user association and seven residents from both villages, for an additional eight people. Participants were selected based on their active role in working with non-governmental organizations to establish the water user associations, or on the personal relationships we had developed with them through the course of our research. We returned in 2011 and conducted interviews with another 45 residents from Palmarejo (67 percent of households,  $n=32$ ) and Palos Blancos (93 percent of households,  $n=13$ ), and included questions about perceived impacts of the 2009 coup d'état on access to water and on the current interest by outside non-governmental organizations in water development projects. In sum, we interviewed a total of 66 individuals from both communities. All interviews were semi-structured, focusing on the technical, environmental, social, and political aspects of water issues and problems. All interviews were conducted in Spanish, face-to-face, and lasted from 30 minutes to two hours in duration. In the discussion that follows, all personal names have been changed to pseudonyms to protect the identities of the study participants. In addition to the interviews, in 2011 we conducted a census of Palmarejo and Palos Blancos, collecting demographic information including age, sex, education, employment, and land ownership for most households. Finally, since 2004, we have amassed hundreds of hours of participant-observation

(recorded through field notes) and informal interviews focused on a wide variety of topics related to resource management and environmental change. While information from participant-observation and informal interviews are not addressed specifically in this article, the results from participant observation have shaped our overall understanding of local resource challenges that we describe.

We also conducted water quality tests, which included inorganic chemical (As, Cd, Hg, Pb, Sb, and Se) and bacterial (presence/absence) analyses of 12 water samples in 2005. This work was followed up in 2006 with additional bacterial tests of 31 water samples using a quantification method that provides counts of total coliform and *E. coli*. Trace elemental analysis was conducted by the University of Georgia Chemical Analysis Laboratory using a VG Inductively Coupled Plasma Mass Spectrometer (detection limits: As, Cd, Pb = 0.5-2.0 ppt; Sb = 2.0-10 ppt; Hg, Se = 10-100 ppt). Presence/absence tests for bacteria were performed using LaMotte Coliform Test Kits. Bacterial counts were determined using IDEXX Colilert Quanti-Tray/2000, an automated quantification method based on the Standard Methods Most Probable Number (MPN) model, which provides total coliform and *E. coli* counts of 1-2,419/100 ml in an undiluted sample.

Finally, in 2007, we used mapping-grade GPS with sub-meter accuracy to map cultural and environmental features in Palmarejo and Palos Blancos, including natural springs that serve as sources for the quebradas, water holding tanks, concrete or stone retention ponds (**presas**), water pumps, and a network of PVC piping and other modifications that divert water to individual homes (Klinger 2008). A Trimble GPS Pathfinder Pro XR receiver and backpack unit with a TSC1 data logger (using Asset Surveyor software) was used to collect a minimum of 30 GPS points at one-second intervals for all points and lines mapped. The redundancy of point collection minimized the degree of error through a point-averaging process. All observed water features and quebrada segments were also photographed and described in field notes. GPS

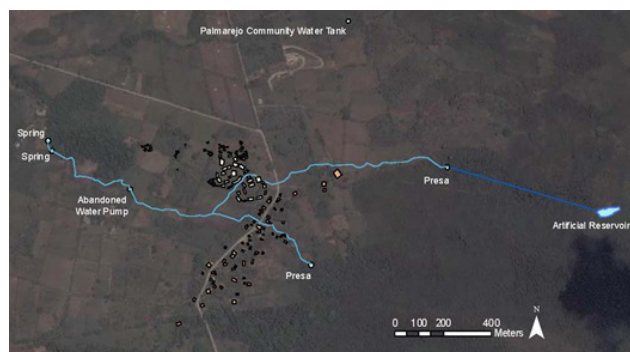
Pathfinder Office 2.90 (Trimble Inc., Sunnyvale, CA, USA) for Windows was used as the native software to retrieve and process data collected in the field. In the lab, the data were exported as ESRI shapefiles for use in a site-specific GIS using ArcMap 9.2 (ESRI, Redlands, CA, USA) for analysis. A hillshade derivative based on a STRM Level 2 (30 m) DEM of Honduras (World Geodetic System 1984, Center for Earth Resources Observation and Science, U.S. Geological Survey) served as the base layer for the maps. An extension for ArcMap called XTools Pro (Data East, LLC, Russia) was used to convert the drawing elements into shapefiles consisting of polygons that represent the various mapped features in the communities.

## RESULTS

Figures 2 and 3 show the mapped cultural and environmental features of Palmarejo and Palos Blancos, respectively. All of the villages in the valley, ranging from 14 houses to about 200 houses, have had their water sources dry up in the past 10 to 20 years, forcing them to search for alternatives. Perceptions among valley residents as to why this has happened vary widely, but residents often reference deforestation from large-scale commercial agriculture and cattle ranching that cross-cut the different communities. Julio, a 49-year-old cattle manager who has lived in Palmarejo for 30 years, recalls:

I have been working here in the hacienda for 16 years. When I came here, I was 19 years old. It was different to what it is now. For example, there was more forest, more water abundance. The water sources were stronger, but in these latest times that we are living... the things have changed a lot, there has been a lot of deforestation, and the water sources have declined, among other things.

Along with Julio, we have found that many other residents are often acutely aware of the broader socioeconomic forces shaping access to water, such as intrusion from outside markets and lack of state or federal regulation. Others, however, suspect that some changes



**FIGURE 2. GPS Map of Palmarejo, including buildings, water features, and nearby archaeological remains (image by William A. Klinger).**



**FIGURE 3. GPS Map of Palos Blancos, including buildings, water features, and nearby archaeological remains (image by William A. Klinger).**

are locally driven, as individuals enter broader markets or seek to take advantage of the lack of governmental oversight in protecting forest and water resources.

The most common solution to the lack of water has been the construction of water distribution systems that connect households to water sources that often lie at considerable distances from communities and that often are subject to the disposition of private landowners. Previously, water was hand-drawn from nearby flowing quebradas. The distribution systems are based on gravity flow with a stream-fed capture tank or spring box connected by PVC to a village storage tank, which is in turn connected by PVC to individual households (Figure 4). Each household typically has one tap (which may be as simple as a hose and a cork) that fills a household storage tank. This water is used for drinking, bathing, and washing. Storage is limited to the capacities of the shared

village tank and individual household tanks. Water is usually shut off every night to allow the village storage tank to refill for use the next day. However, it is often rationed for longer periods, as Carlos Eduardo, a 35-year-old farmer from Palmarejo, laments:

Here, there are so many problems, but now the biggest problem is the water. The problem is that there is water at certain times. For example, right now there is no water, today no water at all. They provide water to one side [of the community] for a certain time, and then to the other side. Days go by, and sometimes the water never gets here.

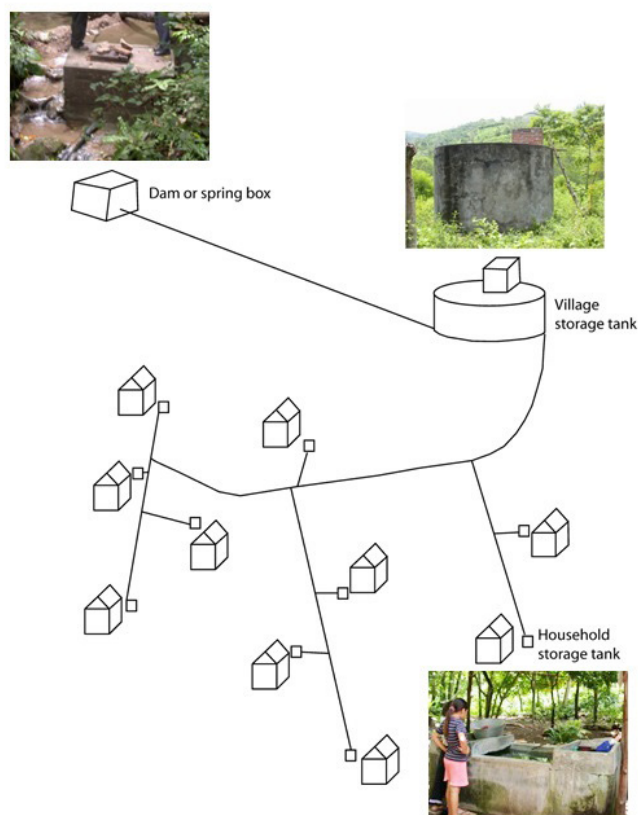
As this case demonstrates, water distribution, while ultimately regulated by the availability of the resource, can become a highly political issue in some communities, with certain individuals experiencing greater control over water access than others.

Despite the high degree of organization exhibited by some of the water user associations, water availability remains tenuous for all the communities. For example, one of the more formal and efficient water user associations, which serves about 200 houses, succeeded in organizing its community members to lay over 3 km of PVC pipe from a capture tank they constructed on a distant mountaintop. However, the water user association remains concerned about water availability and access, because the capture tank sits on land owned by an elderly woman who lives in the U.S. The woman allows community members access to the capture tank currently, but they are afraid that when she dies, her sons will sell the property. In this instance, they could lose access and be unable to maintain their water source. Water access is therefore sometimes linked to land access, and represents one of the broader issues with which

many groups have to contend. In other cases, when highland water sources dry up, community residents are forced to seek alternatives. Samuel, a 66-year-old farmer and resident of Palos Blancos for 40 years, recounts:

The water that was uphill, water that is born there, wasn't enough, and us, having animals, we used too much water. We used more water for the cattle than what we used with the people. So, we needed to build a well. Now we have it there, and if there was the need, if something happens, that well would serve for the community because it's already done. The well is 220 feet deep... and we spent almost 70,000 lempiras [approximately US\$3,500] for it.

In addition to the costs associated with establishing deep cisterns, there is the cost of water extraction. As Samuel notes, "then, the only thing that we need, so we don't spend much in power, which is a problem, is a water pump to get the water out ... that is very expensive, with the electric power, it is so expensive." One of the structural



**FIGURE 4. Typical water distribution system in the Palmarejo Valley**  
(drawing adapted from Gelting and Ortolano 1998:201).

forces thus shaping access to water for some residents is affordability (and, at times, reliable access) to electricity.

As with water quantity and availability, water quality is a problem for all the villages. Albertina, a 56-year-old housewife and lifelong resident of Palos Blancos told us that:

Here what I would love to improve is the problem with water, which is very bad here, the water that we drink. It's over there uphill in the reservoir, where the water source is...that water has to be polluted, because here it is so bad...the source, where the water that we drink comes from.

To evaluate perceptions of poor water quality in Palos Blancos, we tested levels of bacteria in the water at various points along the water system from its source to the last tap, including all households on the distribution system. Although the capture tank is located close to the village, the water originates from a higher mountaintop source. As the spring water flows down, it mixes with laundry water from a large farm and picks up contaminants, such as *E. coli*, from the many cattle pastured there. The PVC pipe channeling the water from the capture tank to the village storage tank lies in this runoff where it is frequently broken by passing people, horses, and especially cows. In addition, many of the houses wrap cheesecloth around their taps to trap particulates such as sand and clay. Unfortunately, the cheesecloth promotes bacterial growth. We found that those houses that used cheesecloth in this manner had significantly higher levels of bacteria in their water supply than households that did not use cheesecloth (Table 1). Bacteria therefore enter the village water supply through leaky pipes lying in contaminated streams as well as through household practices.

Since water quality is being compromised by upstream activities, we also tested for inorganic chemicals in water samples taken from Palos Blancos and two other villages in the valley where we observed water systems connected spatially to outside areas in which farmers were actively using fertilizers and insecticides. While we analyzed a small sample size ( $n=12$ ), all of the samples fell below the maximum contaminant

**TABLE 1. Coliform and *E. coli* counts (MPN) in water samples taken at various points along a single distribution system. (Note: the locations of the sources of the samples have been disguised to protect the anonymity of our informants.)**

Sample	Total Coliform	<i>E. coli</i>
Hacienda spring	1540	87
Upwelling in stream	4	4
Dripping from hillside	12	0
Stream	>2420	>2420
Spring box	53	0
Leaking pipe	391	13
Village storage tank	>2420	2
House 1: washbasin tap	>2420	1
House 2: kitchen faucet	>2420	120
House 2: washbasin tap	>2420	49
House 3: washbasin tap	291	2
House 4: kitchen faucet	534	0
House 4: washbasin tap	>2420	1
House 5: washbasin tap	372	0
House 6: washbasin tap	>2420	3
House 7: washbasin tap	437	1
House 8: washbasin tap	>2420	1
House 9: washbasin tap	291	0
House 10: washbasin tap	326	2
House 11: washbasin tap	437	1
House 11: kitchen faucet	>2420	0
House 12: shower	91	2

levels set by WHO (2012b) and the EPA (2012), with the exception of samples 1, 7, and 8, which had values of antimony (Sb) higher than EPA (but not WHO) standards (Table 2). The source of Sb, while unconfirmed, may be linked to the use of antimony potassium tartrate, a toxic compound found in some insecticides (Green and Pohanish 2005:61-62).

## DISCUSSION

All of the water problems in the Palmarejo Valley as described above—namely insufficient quantity, limited availability, and poor quality—derive from a mix of local practices coupled with broad, long-term social, economic, and environmental processes (e.g., Gareau



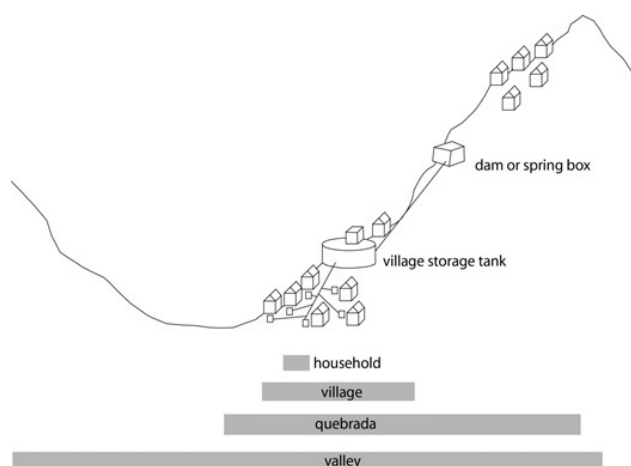
**TABLE 2. Levels of inorganic chemicals found in water samples taken from three villages in the Palmarejo Valley. Guideline values for each chemical set by the WHO (2012b) and EPA (2012) are provided in parentheses. (Note: the locations of the sources of the samples have been disguised to protect the anonymity of our study participants.)**

Sample	Village	Source	As (WHO=20, EPA=6)	Cd (WHO=10, EPA=10)	Pb (WHO=3, EPA=5)	Sb (WHO=10, EPA=15)	Hg (WHO=1, EPA=2)	Se (WHO=10, EPA=50)
1	A	house	10.970	8.001	>1.000	5.025	.910	1.624
2	B	house	.207	>1.000	>1.000	1.495	.644	.307
3	B	spring box	.226	>1.000	>1.000	.518	.663	1.667
4	B	house	.168	>1.000	>1.000	.174	.406	1.593
5	C	spring	.271	>1.000	>1.000	>1.000	.423	2.414
6	C	cattle tank	.139	>1.000	>1.000	>1.000	.356	.410
7	A	spring box	8.104	2.826	>1.000	>1.000	.418	.412
8	B	pond	11.040	5.884	>1.000	>1.000	.399	.270
9	C	spring box	.171	>1.000	>1.000	>1.000	.265	.689
10	C	village tank	.303	>1.000	>1.000	>1.000	.291	.945
12	town	house	.195	>1.000	>1.000	>1.000	.316	>1.000

Note: All data are reported in µg/L.

2007). For the residents of the Palmarejo Valley, these include: 1) land use patterns, including local and commercial agriculture and cattle ranching that result in deforestation, which leads to landscape desiccation; 2) the politics of water control and distribution on local (“community”) and regional (multiple “communities”) levels; 3) unreliable long-term access to property where springs or other water sources emerge; 4) the economics of water access sometimes linked to other resources, such as electricity; and 5) cultural practices and natural processes that compromise water quality, including land and water use in one region that impact the resource in another region.

These processes impact the water supplies of the Palmarejo communities at four sociospatial scales: household, village, quebrada, and valley (Figure 5). The existing water systems physically span three of these scales, over only one of which do the water user associations exert some degree of control—the village, manifest in the shared storage tank. Water problems, however, originate at all four scales. At the scale of the household, there is no way to store water beyond the capacity of the household storage tank and no way to control the quality of the water except to boil or add chlorine, both of which are expensive options for residents. At the scale of the village, the size of the shared storage tank restricts what is available on a daily basis. Some households, such as those at higher elevations than the tank and those at the end of the system, re-



**FIGURE 5. Schematic of the sociospatial scales at which the water supplies of the Palmarejo Valley are impacted.**

ceive less water than other village residents. Moreover, all residents are subject to the oft-politicized decisions about water allocation made by a single individual or a small group. At the scale of the quebrada, downstream users are affected by the socioeconomic and political actions of their upstream neighbors, including individual landowners and inhabitants of other villages, who may limit access to system components, use too much water, and/or contaminate the water source from which a downstream village’s capture tank draws. Finally, at the scale of the valley, pastoral and agricultural intensification and accompanying deforestation have diminished stream flow throughout the valley. The complex interplay of these factors shifting among scales challenges the community-based water



user associations that are potentially not equipped to handle problems arising from other scales—over which they exert no control and for which they ultimately are not responsible.

Thus, the Palmarejo Valley case calls into question the sustainability of the community-level approaches to water development currently employed elsewhere. The Palmarejo systems were community planned, designed, organized, implemented, and in most cases financed, yet they still experience many of the same problems in other rural Honduran regions. If, as in the Palmarejo Valley, the water problems affecting other Honduran communities stem from broader socioeconomic forces, including diminished funding for national development initiatives and conflicts in regional integration of coordinated development (e.g., Loker 1998; Phillips 1997; Stonich 1989; Trevett et al. 2004), then current technological solutions remain a temporary patch for a much larger problem. Alternative organizational models of water management that take into account the social, political, and economic problems that accompany scale challenges are needed to improve access to safe drinking water.

The information we have gathered from our interviews with local residents and our observations of current land tenure and use patterns indicates that, despite the proactive efforts by the villages of the Palmarejo Valley to secure adequate water supplies for their residents as populations and demands on resources grow, ultimately those supplies are in jeopardy, because the scale at which the village water user associations operate is too narrow to combat the cross-scale forces impacting their water supplies. Residents appear to be variably aware of some of these forces, as are NGOs that also operate in the valley, but neither set of actors is able to grapple effectively with this multidimensional focus. In the end, both sets of actors are forced to work at social and geographic scales amenable to their financial, human, and social resources, which are being ever tightly pressed after the 2009 coup d'état and the wave of escalating violence that is

increasingly driving out NGOs from the country (Euraque 2010).

The broader implication of the Palmarejo data is that development efforts in the region and elsewhere may need to redefine their understanding of “community” in community-based approaches, and scale up their efforts where appropriate. The community-by-community approach currently employed defines communities as bounded social units with clear spatial boundaries (Cleaver 2001:44), which are then used to define the limits or extent of the water system. For example, the pipe for a water distribution system is laid to the edge of town where the last house is found, or a public standpipe is constructed in the geographic center of a town. This limited view of community neglects social and political networks and activities that extend beyond visible spatial limits to agricultural fields, forests, river, roads into the city, and so on, all enveloped by broader social relations that impact the quantity and quality of water resources. However, we are not arguing that a limited view of community makes water planning ineffective. Rather, we suggest that community-scaled approaches are unable to mitigate the pressures on water resources that emerge in and extend to other scales, because they cannot adequately recognize and attend to cross-scale dynamics (Cash et al. 2006).

To improve the current water situation in the Palmarejo Valley and elsewhere, change clearly needs to occur at multiple scales. Though this article did not thoroughly address the smallest scale of the household nor the largest scale of the basin, these scales are equally important for improving water quantity and quality. For example, household water management is increasingly being targeted by public health programs and others to reduce water-borne diseases (Clasen and Cairncross 2004; e.g., Trevett et al. 2004), while integrated water resource management employs a participatory approach at the basin scale to combat the various forces affecting water supplies (Peña 2011; e.g., Olivas and McClain 2005). Just as particular technologies are more appropriate for some environ-

ments than others, so too are particular organizational scales more appropriate for some socio-environmental contexts than others.

The Palmarejo case also suggests the need to consider alternative models of resource management, such as those discussed by Tucker and Ostrom (2005), for example, which emerge from the analysis of the institutions (formal and informal rules) that govern common-pool resource use. With the construction of modern water systems by some development projects in the region, there appears to be an underlying assumption that centralization and hierarchy in management are a more efficient means of organizing labor and resources (Sano 2009). In contrast, we have found that water management in Palmarejo and Palos Blancos is organized based on the shared use of particular resources without reliance on a hierarchical management system (i.e., *juntas de agua*). Similarly, historical research in the valley suggests that, in the past, valley inhabitants managed resources at the scale of the quebrada, or microwatershed (Wells et al. 2013), which suggests a more holistic awareness of the interdependencies of water, land, and people at multiple scales.

If a dependency on community-scaled technological solutions to water resource problems has obscured the utility of alternative models of water management for communities in Palmarejo (e.g., Heynen et al. 2007; Loker 2000), then it may be time to consider broader social and spatial scales in the valley. These more encompassing approaches, however, have their own sets of logistical challenges, such as land access and management organization, which some groups are able to navigate effectively on behalf of water provisioning in their communities while others are not. One promising avenue for future development efforts is systems dynamics simulation approaches (Winz et al. 2009), which attempt to integrate into a single model the salient features of regional water resources including sociopolitical and economic factors, natural processes, and the physical lifecycles of engineered systems along with their products and wastes. These approaches seem poised to account for the intricate and multidimensional relationships between the social-technical organization of the hydrosocial cycle (Linton 2014;

Linton and Budds 2013) and the power contests that structure access to and exclusion from water (MacKinnon 2010; Swyngedouw 2009). For these kinds of modeling efforts to prove useful, however, social scientists will need to work more closely with ecologists and engineers than they have in the past (Lowe et al. 2013; Norman et al. 2012; Wells et al. 2014).

From these observations, we conclude that sustainable water management approaches can only emerge when practitioners develop the ability to understand the contexts, conditions, and—most importantly—the social and spatial scales at which people make decisions about resource use (cf. Bourdieu 2000). We propose that development planning agencies may find more sustainable solutions to water resource challenges if communities are recognized not as internally homogenous and externally bounded entities but as historically changing networks of actors and institutions operating according to diverse motivations and desires. Communities, like water itself, are fluid and permeable.

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