The mismatch of narratives and local ecologies in the everyday governance of water access and mosquito control in an urbanizing community

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ABSTRACT

Mosquito-borne disease presents a significant threat to urban populations, but risk can be uneven across a city due to underlying environmental patterns. Urban residents rely on social and economic processes to control the environment and mediate disease risk, a phenomenon known as everyday governance. We studied how households employed everyday governance of urban infrastructure relevant to mosquito-borne disease in Bengaluru, India to examine if and how inequalities in everyday governance manifest in differences in mosquito control. We found that governance mechanisms differed for water access and mosquitoes. Economic and social capital served different roles for each, influenced by global narratives of water and vector control.

Keywords: mosquito ecology, water access, vector control, everyday governance

INTRODUCTION

Urbanization transforms nature into environmental amenities via social, biophysical, and political processes (Lawhon et al. 2014). The process of urbanization, however, is laden with inequalities, especially in peripheral urban areas (Caldeira 2017, Pandey et al. 2022). Environmental amenities, in particular, "may be enhanced in some places and for some people [by urbanization], lead[ing] to a deterioration of social and physical conditions and qualities elsewhere" (Swyngedouw 2004). These patterns in environmental resources, and peoples' ability to govern them, can have direct and indirect effects on human health (Douglas 2012). For example, changes to the environment resulting from urbanization can affect mosquito population dynamics through the creation of artificial habitat, reduction of natural mosquito predators, and reduced competition with non-vector mosquito species (Wilke et al. 2021), leading to spatial patterns in mosquito-borne disease risk. This is notably the case for dengue, a mosquito-borne disease that causes hemorrhagic fever, which is considered to be primarily an urban disease (Gubler 2011, Charette 2016, Kolimenakis 2021) and is often characterized by spatial heterogeneity across a city (Telle et al. 2016, Lippi et al. 2018).

Being closely tied to the environment via a mosquito vector, mosquito-borne disease risk varies across space as a result of underlying spatial patterns in environmental factors, such as vegetation (Huang et al. 2018), aquatic habitat (Akanda et al. 2020), and temperature (Telle et al. 2021). Mosquitoes lay their eggs in stagnant water, including drainage, water storage containers, and solid waste, and increases in available habitat for larvae are closely tied to increases in mosquito abundance (Wilson et al. 2020). While some studies have found that piped water decreased risk of mosquito-borne disease (Hayden et al. 2010, Schmidt et al. 2011), others have found piped water to increase the risk of disease (Lippi et al. 2018), especially if service is intermittent, which encourages water storage (Stewart-Ibarra et al. 2013). It is not simply the formal water infrastructure that impacts mosquito abundance, but also the everyday practices people rely on to access water. In addition to water infrastructure, the availability of vector control services, including larval source management via solid waste removal or insecticide, influences the abundance of dengue vectors across a city (Reiner et al. 2019, Piovezan et al. 2019, Rehman et al. 2020). Both of these services - water provision and vector control - are parts of urban sanitation infrastructure that transform the environment, and unequal distribution of these services can manifest in differences in disease risk. Such inequalities can reproduce existing power relations and interactions across axes of power (e.g., Bakker et al. 2008, Adams et al. 2018). These interactions constitute systems of everyday governance in urban contexts (Blundo and Le Meur 2009)

Systems of everyday governance of water infrastructure and vector control

Simultaneously studying the everyday governance of water and vector control is one way to trace the connection from underlying patterns of social and economic power to patterns in mosquito abundance and disease exposure. Everyday governance in cities encompasses a broad set of practices and negotiations among state actors, non-state actors, and urban residents that result in the transformation of local social and ecological environments (Blundo and Le Meur 2009, Cornea et al. 2017). Everyday governance is a dynamic system of norms, including formal regulations and unwritten social codes, whose relations of accountability and responsibility are negotiated, and renegotiated, along diverse axes of economic and social capital (Bénit-Gbaffou and Oldfield 2011). Mosquito burdens, and the urban infrastructure that supports them, therefore represent an interesting lens through which to study the processes of everyday governance of urban environments. Particularly in urbanizing areas, understanding how everyday governance of these resources functions at the intersection of global narratives (e.g. how responsibilities and rights to infrastructure are framed), state actors, and residents' everyday practices can identify populations that are excluded from these services, and therefore more vulnerable to mosquito-borne disease (Connolly et al. 2020).

Historically, the development of sanitation infrastructure has served as a means of state-building, as it facilitates government control of local environments and people. State-building was both abstract and literal, an example being the large-scale drainage works of the British government in Lagos (Gandy 2006). These development projects increased colonial government power in the abstract through the process of government centralization and economically through the creation of new lands and assets for the colonial government via reclamation of swampland into government-owned land. It has also served to strengthen the position of non-state actors, such as the rise of the Rockefeller Foundation following its role in vector control supporting US government and business interests in Latin America (Franco-Agudelo 1983). Water and sanitation infrastructure continues to serve the modern state; in post-independence Mumbai, the construction of a large-scale water project served to illustrate the "technocratic omnipotence" the new Indian national state hoped to achieve (Gandy 2008). The creation of water infrastructure is therefore a recognized tool of power accumulation by the state (Meehan 2014). However, it has also been recently defined as a "human right" and therefore a responsibility of the state in global discourse, particularly as defined by the United Nations and other international governing bodies (Neto and Camkin 2020). Everyday governance of water and sanitation is therefore influenced by these, sometimes competing, perspectives concerning the role of the state in peoples' access to water.

While both water and vector control are general considered part of a larger sanitation and hygiene infrastructure, the narrative of vector control is further complicated due to its origins in public health and tropical medicine, in particular. In certain contexts, tropical medicine was used to justify colonial government polices that placed non-Europeans apart as an Other, a non-human object to be studied and regulated by colonial governments (Anderson 1996). Those in close proximity to disease could therefore be described as "unclean" and "immoral", establishing a link between an individual's health and behavior or identity (Garcia Jr. 2013, Engel and Susilo 2014). With the dawn of technological solutions to mosquito-borne disease and policies that reduced state responsibility for public health in favor of individual 'responsibilization' (Hache 2007, Ilcan and Phillips 2010), vector control became an issue of "compliance" (Guglielmo et al. 2021). In certain instances, non-compliance has evolved into a topic of biosecurity, a domain of the state. For example, during the Zika epidemic, governments employed a combination of military intervention and civic responsibility campaigns, increasing government control over domestic spaces while simultaneously increasing individual accountability for them (Pinheiro de Oliveira 2016, Rivera-Amarillo and Camargo 2020, Patchin 2020). In this case, vector control was at once defined as the responsibility of the individual and a tool of state, complicating an analysis of everyday governance practices and their relation to spatial heterogeneities in disease risk. At the household level, who is responsible for the management of mosquito vectors and who is capable of doing so?

Spatial inequalities in urban governance of water infrastructure have been well-studied, particularly in cities. Bakker (2003) identified water infrastructure in Jakarta as a heterogeneous network across gradients of corporate and community control, stemming from a biophysical legacy of colonial water infrastructure (Kooy and Bakker 2008) and choices by both water providers and households (Bakker et al. 2008). In Delhi, an everyday governance lens revealed the nuanced roles played by non-state actors, who occupy a hybrid position encompassing both state and non-state authorities, and how citizens navigate the politics of these supposedly "non-political" relationships (Truelove 2020). Sultana (2009, 2020) explored how these everyday negotiations and the resulting consequences of not accessing water are highly differentiated across multiple axes of identity, particularly class and gender. Within a city, access to water is also a form of 'hydraulic citizenship' (Anand 2011), with both the practices used to access water and the resulting materiality of water itself serving as markers of belonging . For example, in Bengaluru, households took part in "payment-for-pipes" water programs to claim citizenship and formalize land tenure, actively constructing their legitimacy as constituents of local government actors (Ranganathan 2014). Importantly, these approaches to everyday governance of water recognize the active role of households and individuals in negotiations for water access, not as passive recipients, and the diverse ways in which they achieve that access depending on their situated identities. Governance of vector control has primarily focused on institutions at national or local levels (e.g. Shaw et al. 2010, Tedesco et al. 2010), rather than using an everyday lens to consider the role of individuals and the everyday micro-politics and practices they use to access vector control. Given the vast literature on everyday governance of water and its close relationship with mosquito biology, a comparative study of both water and health governance can benefit from the prior work on water governance by identifying similarities and differences between the two (Gondhalekar et al. 2013).

This study leverages the framework of urban everyday governance to critically analyze differences in households' abilities to access water and mosquito control and how these practices are related to mosquito burdens within the context of urbanization. The goal of this study was to explore how the social processes of everyday governance relate to mosquito abundances across space, and identify potential reasons why governance practices may result in inequalities in mosquito burdens in cities. . Drawing on five months of field observations, in-depth interviews, and entomological surveys, we explored how households wield social and economic power in their negotiations of access to water and mosquito-free space via vector control. We used a narrative approach to compare everyday governance practices across households, paying particular attention to differences in social and economic power. The entomological surveys were then used to assess whether differences in governance practices translate to differences in mosquito burdens. Finally, we considered the relative success of everyday governance practices related to water and vector control in the context of their respective governance narratives at a global scale.

METHODS

Study Site

Sarjapur is a town located at the southeastern periphery of Bengaluru (Karnataka, India), a city of approximately 12.2 million people characterized by outward growth into the rural and peri-urban periphery (Verma et al. 2017, Ramachandra et al. 2020). Bengaluru itself has witnessed a steady increase in dengue cases over the past two decades (Chakravarti et al. 2012), and both water access and dengue burden are unequally distributed across the city (Mehta et al. 2014, Balakrishnan 2016, Damodaran 2019). The primary mosquito vectors of dengue in Bengaluru and the surrounding area are *Aedes aegypti* and *Aedes albopictus,* often found in "domesticated" habitats such as solid waste or water storage containers (Balakrishnan et al. 2015). Sarjapur Road is the site of multiple Special Economic Zones (SEZs), which offer state and local tax and regulation benefits to developers of the zones and corporations housed within the zone. The establishment of SEZs in previously rural areas has been accompanied by the development of residential communities, known locally as "colonies", consisting of individual single-family homes that primarily house white-collar workers living in gated societies. The SEZs in Sarjapur are projected to employ over 34,000 people upon completion, driving migration and development in a town whose population was approximately 12,000 at the last census (Census of India 2011). Indeed, the 2031 Bengaluru Municipal Development Plan proposes to rezone the area from majority agricultural land use designations to only residential and industrial land use designations due to projected urbanization.

Underlying this broad pattern of economic development and urbanization is a heterogeneous urbanization process. Sarjapur consists of patches of villages within the urban matrix (Fig. 1), which complicates the classification of neighborhoods into rural or urban. We structured the spatial distribution of our entomological sampling and interview recruitment with an attention to these differences in the human and mosquito environments across space. Nagendra et al. (2013) used housing type as a "dimension of rurality in lifestyle" in an analysis of urbanization in Bengaluru, specifically the presence of one-story, sloped roof, traditional style houses within the city that were often built prior to the recent urbanization boom. In Sarjapur, the presence of traditional, village-style housing is associated with older, more rural residential neighborhoods within the city. Mosquito abundance is correlated with changes in microclimate and habitat across impervious surface gradients (Murdock et al. 2013, Evans et al. 2019). Therefore, we chose twelve sites that incorporated a range of impervious surface and housing types and assigned them into three categories: village (village-style housing, low impervious surface), town (village-style housing, high impervious surface), and colony (Western-style housing, low impervious surface) (Fig. 1). The study region was divided into four geographic blocks radiating north, south, east, and west along transportation networks from the commercial center of Sarjapur. We stratified site selection so that each block contained one site of each category and chose sites at least 1 km from sites of the same category, so that sites of the same category were geographically distributed throughout the study area. However, given the layout of Sarjapur, sites in town were necessarily closer together than 1 km (mean distance = 717.03 m), while still representing distinct neighborhoods.

Our final set of sites included a range of household identities, water infrastructures, and mosquito habitats to ensure our sample was representative of Sarjapur's diverse urban landscape. Participants ranged in age from 19 to 75 years old and included 12 women and 9 men. Twelve families were native to Sarjapur and had lived there for multiple generations. Participants held a variety of occupations, including IT, education, agriculture, security, and taxi driving, and formal educational attainment levels ranged from none to a graduate level. Participants therefore occupied different positions on different axes of power (e.g. capital, social, political, etc.), and potentially leveraged these positions in a variety of ways via everyday governance (as detailed in the discussion).

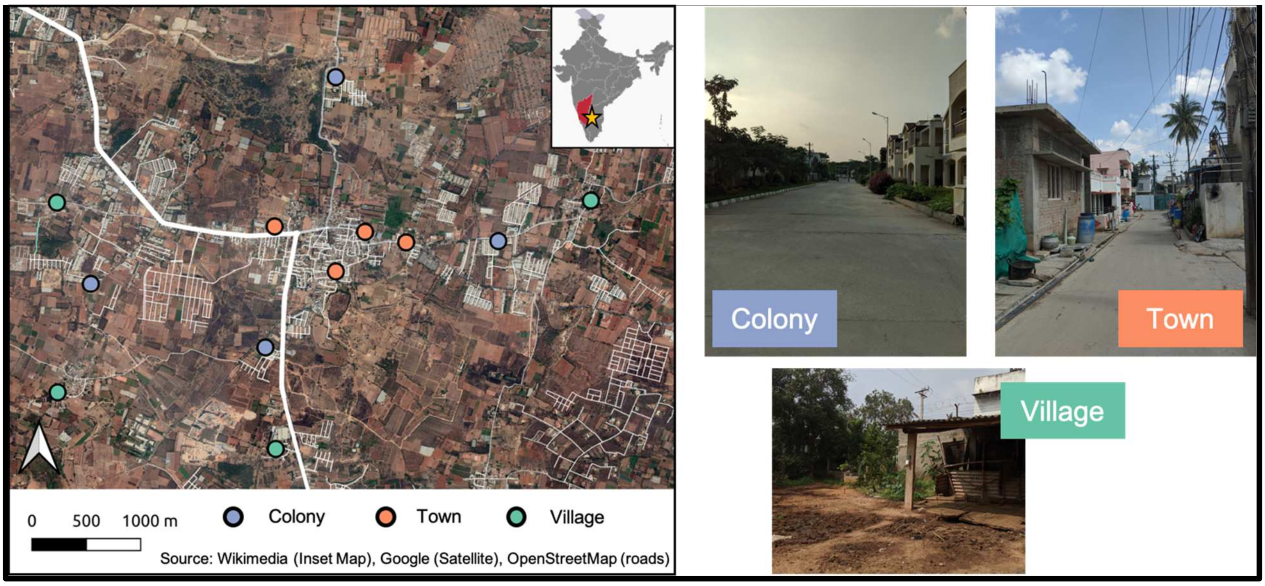

Figure 1. Location and characteristics of sites. A) Map of Sarjapur town with twelve sites denoted with colored circles. B) Photographs of example landscapes for the three site categories depicting differences in impervious surface and housing types.

Data Collection and Analysis

During five months of field work (August - December 2019), we studied the differences in water access and mosquito burdens across Sarjapur through a combination of observations, semi-structured interviews, and key informant interviews. We conducted semi-structured, in-depth interviews with 21 households and three key informants. Interviews aimed to elicit descriptions of how households negotiate access to water and mosquito vector control, and how water practices relate to mosquito risk in their surrounding environment. Transcribed interviews were analyzed using a narrative approach (Silverman 2003, Wiles et al. 2005), resulting in a contextualized thematic analysis about community members' experiences accessing water or interacting with mosquitoes. In addition to the in-depth interviews, interviewees participated in a mapping exercise where they identified the spatial location of water infrastructure and mosquitoes and discussed the relationships between the two. This mapping exercise encouraged participants to focus on the fine scale spatial distribution of water infrastructure and mosquito burdens within their neighborhood, drawing attention to spatial patterns of inequality. Sketch maps were manually georeferenced, and sites of water access and mosquito burden were digitized into geolocated polygons using QGIS (Open Source Geospatial Foundation Project 2020). These maps were used in combination with interview transcripts to assess the spatial pattern and abundance of water access sites and mosquito habitat.

Interviews were in-depth and semi-structured, following questions regarding the topics described above using an interview guide (see Supplemental Materials). Participants were recruited for interviews via a combination of spatial stratification across housing types (a form of purposive sampling), opportunistic sampling, and snowball sampling (Stratford and Bradshaw 2016). This approach allowed us to legitimize our presence in the community while ensuring recruitment of a group of participants that represented variation in water access practices (Ellard-Gray et al. 2015). To achieve spatial and housing type stratification, two households were interviewed at each site, except for three colony sites, where only one household was interviewed. These colony sites consisted of one housing type and were managed by a single developer, so that water infrastructure was identical across residents. Interviews ranged from 25 to 90 minutes in length and were conducted in Kannada, Hindi, and English. All interviewees were adults over the age of eighteen and managed their household's water in some capacity. Prior to each interview, we obtained verbal consent from participants. This study was approved by the Indian Ministry of Home Affairs and the University of Georgia's Institutional Review Board.

In addition to qualitative data collection, we also sampled mosquito populations at each site using standard entomological procedures for adult mosquito trapping with CDC light traps. From these traps, we estimated the relative abundance of mosquitoes at each of our sites from the number of mosquitoes caught during a 24-hour trapping period. For a more detailed analysis of this information, please see our parallel study (Author 2022).

Two researchers (Author1 and Author2) conducted the fieldwork involved in this study. As Author1, a white, American woman, and Author2, an Indian man, were both outsiders to the community being interviewed, we necessarily write from a "foreign pose for a foreign gaze" (Abimbola 2019). We aim to center and value the contributions and knowledge of local community members while questioning hegemonic Western narratives. However, we recognize that our standpoint and identities necessarily limit our ability to do so given our identity as members of the academy trained in fields with a legacy of colonial knowledge practices and, for some of us, as American citizens conducting research in India (Harding 1987, Smith 2012, Abimbola et al. 2021).

RESULTS

Everyday governance of water

Most households (17/21) were satisfied with their current water acquisition system, initially reporting "no problem". However, as is detailed below, initial responses of "no problem" matured into more critical evaluations of each individuals' access to water throughout the course of the interviews, as the details of their everyday governance practices were explored more in-depth. The differences in water access across Sarjapur closely align with whether water is provided by the local government panchayat (public) or a private provider. Panchayat water is provided free of cost to those who live in individual houses or smaller apartment buildings, while private water is provided for a fee by the development manager or residential association of a colony development or via private water tankers hired by individuals. All residents of villages and residents of three of the four neighborhoods surveyed in town had access to a panchayat water tap. In general, private water was provided more regularly and was considered more reliable than panchayat water (Table 1).

Table 1. Table of house and water system characteristics and mosquito abundance data from three months of trapping at twelve sites in Sarjapur in 2019. With the exception of three colony sites, two interviews were conducted at each trapping location.

<table>
<tr><th rowspan="2">Land Class</th><th rowspan="2">Building Type</th><th rowspan="2">Property Owner</th><th rowspan="2">Private Water</th><th rowspan="2">Community Sump-OHT</th><th rowspan="2">Individual Sump-OHT</th><th rowspan="2">Water Frequency</th><th colspan="3">CDC Trap Mosquito Abundance</th></tr>
<tr><th>Sept.</th><th>Oct.</th><th>Nov.</th></tr>
<tr><td>Colony</td><td>>10 level Apartment</td><td></td><td>X</td><td>X</td><td></td><td>24/7</td><td>92</td><td>36</td><td>17</td></tr>
<tr><td>Colony</td><td>>10 level Apartment</td><td>X</td><td>X</td><td>X</td><td></td><td>24/7</td><td>4</td><td>78</td><td>71</td></tr>
<tr><td>Colony</td><td>Western House</td><td>X</td><td>X</td><td>X</td><td>X</td><td>24/7</td><td>674</td><td>180</td><td>13</td></tr>
<tr><td>Colony</td><td>Western House</td><td>X</td><td>X</td><td>X</td><td>X</td><td>24/7</td><td rowspan="2">599</td><td rowspan="2">53</td><td rowspan="2">46</td></tr>
<tr><td>Colony</td><td>Western House</td><td>X</td><td>X</td><td>X</td><td>X</td><td>24/7</td></tr>
<tr><td>Village</td><td>2-level Apartment</td><td></td><td>X</td><td>X</td><td></td><td>Daily</td><td rowspan="2">20</td><td rowspan="2">2</td><td rowspan="2">10</td></tr>
<tr><td>Village</td><td>Multi-level House</td><td>X</td><td></td><td></td><td>X</td><td>Daily</td></tr>
<tr><td>Village</td><td>Traditional House</td><td>X</td><td></td><td></td><td></td><td>3-4 Days</td><td rowspan="2">227</td><td rowspan="2">157</td><td rowspan="2">183</td></tr>
<tr><td>Village</td><td>Traditional House</td><td>X</td><td></td><td></td><td>X</td><td>3-4 Days</td></tr>
<tr><td>Village</td><td>3-level apartment</td><td></td><td>X</td><td>X</td><td></td><td>24/7</td><td rowspan="2">79</td><td rowspan="2">53</td><td rowspan="2">NA</td></tr>
<tr><td>Village</td><td>Traditional House</td><td>X</td><td></td><td></td><td>X</td><td>3-4 Days</td></tr>
<tr><td>Village</td><td>Traditional House</td><td>X</td><td></td><td></td><td></td><td>Daily</td><td rowspan="2">206</td><td rowspan="2">1</td><td rowspan="2">2</td></tr>
<tr><td>Village</td><td>Traditional House</td><td>X</td><td></td><td></td><td></td><td>Daily</td></tr>
<tr><td>Town</td><td>2-level apartment</td><td></td><td>X</td><td>X</td><td></td><td>24/7</td><td rowspan="2">1912</td><td rowspan="2">2</td><td rowspan="2">72</td></tr>
<tr><td>Town</td><td>Multi-level house</td><td>X</td><td>X</td><td></td><td>X</td><td>24/7</td></tr>
<tr><td>Town</td><td>Sheet House</td><td></td><td></td><td></td><td></td><td>2 Days</td><td rowspan="2">122</td><td rowspan="2">3</td><td rowspan="2">0</td></tr>
<tr><td>Town</td><td>Sheet House</td><td></td><td></td><td></td><td></td><td>2 Days</td></tr>
<tr><td>Town</td><td>Sheet House</td><td>X</td><td></td><td></td><td></td><td>5-7 Days</td><td rowspan="2">81</td><td rowspan="2">59</td><td rowspan="2">55</td></tr>
<tr><td>Town</td><td>Traditional House</td><td></td><td></td><td></td><td></td><td>5-7 Days</td></tr>
<tr><td>Town</td><td>1-level apartment</td><td></td><td>X</td><td>X</td><td></td><td>24/7</td><td rowspan="2">55</td><td rowspan="2">79</td><td rowspan="2">55</td></tr>
<tr><td>Town</td><td>1-level apartment</td><td></td><td></td><td></td><td></td><td>3-4 Days</td></tr>
</table>

The driving cause of inequality in water access was not the source of household water, but differences in water storage capacities at the household level, particularly underground cement sumps and overhead tanks (OHT). In the private developments we surveyed, all households contained individual sump-OHT systems, which allowed for individual capacity to cope with water stress. As one colony resident described: "This is an individual house, so I'm sure I have enough in my tank. Water is there. At any time, if I open the tap, water will come" [S02]. Within the town and villages, there was much more heterogeneity. Sumps are generally installed in "big houses", which are newly built, often multiple stories, and owned by wealthier families. As one community member noted, "people who put more money [into their house] have less problems [with water] than those who don't" [P02]. Due to the infrequent supply of public water (ranging from daily to once a week), those without sumps face more water hardship than those with sumps:

> "But think about it, if water does not come to my house, I cannot do anything about it. People with sumps, they anyway have storage so they're fine. When something like that happens, I can't wash the dishes, I can't wash my house, I can't bathe." [T01]

This combination of public and private water access complicates the system of water governance in Sarjapur and is emblematic of systems of everyday governance seen in other urban peripheries (e.g. Caldeira 2017, Truelove 2020). Wealthier households living in private housing developments relied primarily on economic capital to access water, paying monthly fees to the development corporations for continued access to water. Those who relied on municipal water, on the other hand, employed a mix of social and economic capital in their everyday governance practices.

To wield social capital, residents used several identities to frame themselves as members of the larger abstract *public* to whom the local government is assumed to be accountable. For example, some households mentioned that the politicians should be accountable to them as part of the electorate: "In the panchayat, there will be the person who won the election here, right? If I tell them [piped water is not coming], they'll send tankers" [H03]. Rather than formal displays of citizenship, the most common identity leveraged to exert accountability over the local panchayat with regards to water provision was a claim to membership of the local community, an abstract *public* that is not necessarily defined by formal actions of citizenship, but by shared identities. Members of the panchayat are drawn from this local community, and participants expressed multiple forms of shared identity with the politicians who represent them. Many were neighbors with panchayat members and felt comfortable approaching them when water was not supplied:

> "The panchayat chairman. She happens to be a lady too. She lives right here, she'll solve our problem...We have their [panchayat members] phone numbers. I know their house itself, so I have sometimes gone up to them and just told them [when there is a problem]." [L02]

> "The sarpanch (chairman of panchayat), yes, he had constructed a large overhead tank. If there is any problem with our sump, we go and talk to him. If there's any problem, I go to the chairman. Water-related. Any issues with this and that, I go to him." [K02]

> "If there's something that needs to be changed or something has broken, then I'll go and talk to the "big man"… He is the father to this village." [T01]

These community members identified two forms of shared identity, gender and shared membership in the local community, that they could leverage when approaching the local government members. In fact, multiple participants recounted times when they successfully advocated for their water rights with the local government, whether it was concerning access to public faucets, water frequency, or water quality.

Participants without sumps recognized the inequality in water access between houses with sumps and without sumps and often identified themselves as victims of water hardship to advocate for changes to municipal water supplies, specifically frequency:

> "We who have 'sheet' houses [houses with corrugated tin roofs that do not have OHT-sump systems, generally lower-income households] are the ones who normally face the brunt of the water problem." [L01]

> "One more problem is that "big-big" people, rich people, they have sumps. They get a lot of water, the water just goes into their sumps and they can store it. So for them, whether water is supplied everyday or not, it doesn't matter, they would have filled up their entire sump…. For them, because they have these things, they can store water. However, for us middle-class people, we are not helped. Lifelong, we won't have any help." [T02]

These passages highlight the inequality among those who rely on municipal water created by differing abilities to build a sump (i.e. economic capital). In addition, it demonstrates how those without sumps leverage their social identity as residents of middle and lower economic classes as a form of social capital to demand more frequent provision of water. While, in theory, municipal water connections are equally available to all houses via their membership in the local community (social capital), the physical access to daily water and ability to use it is mediated by a household's wealth via their ability to afford constructing a sump.

Everyday governance of mosquitoes

When asked about the primary drivers of mosquitoes in their neighborhood, participants implicated unmanaged vegetation (9/21), drainage (11/21), and garbage (13/21). No community members identified their own individual practices as a cause of mosquitoes. Rather, community members attributed mosquitoes to the inadequate or non-existent drainage systems and lack of cleanliness in public spaces, specifically garbage and unmaintained vegetation, or “shabby gardens” [S01]. These were the areas most often identified during the mapping exercise as sources of mosquitoes (Fig. 2). However, not all vegetation or drainage was marked on these maps and community members tended to mark areas near their home that were public land, rather than their own property. The responsibility for that land, however, is complicated:

> “Why is this happening, right? Because they [other community members] are not taking the responsibility. They are thinking in their home, they maintain a clean cleanliness, but outside they will throw whatever. They are not taking responsibility. The government will not take initiative.” [H02]

Because it is public land, this community member places the responsibility for that land on the abstract “they” as well as the state. This narrative was repeated by other community members when describing public spaces:

> “There’s so much garbage that has been thrown here. Even if you want to clean, we won’t be able to clean it. ... if we just call up the municipal office, only if we pay them some money will they come and clean it up. That is their duty, right, to clean it. Why should we do it? We can’t give for anything and everything.” [V01]

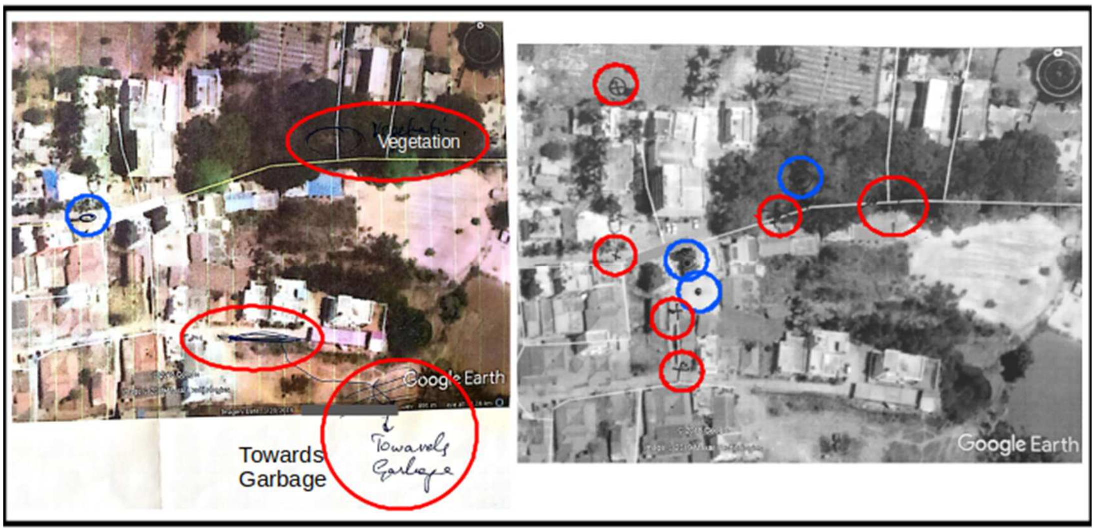

Figure 2. Example of two sketch maps from one village site. Colored circles representing household water access (blue) and areas of mosquito habitat (red) have been added to increase visibility on digitized copies and some words handwritten words have been typed. All identifying information (road names, coordinates, etc.) has been removed.

In both instances, community members explicitly place the responsibility for these mosquito-producing areas on the local government. This is similar to the strategies employed by community members to access municipal water, but with a slightly nuanced difference. Town residents constructed their own identities to gain access to water, with the assumption that the state will provide water to its citizens, while residents' statements regarding waste collection and land management construct the identity of the state as an institution that is responsible for this service. In practice, however, this strategy was often ineffective, as one resident recounted a failed attempt to involve the government using a formal claim to citizenship:

> “I have told the panchayat three times to clean it [solid waste blocking the drainage], they have not done anything though...I have taken him to the exact spot where this accumulation is happening, but no action has been taken...Whether we write an arzi [formal petition] to the panchayat, or don’t write, it doesn’t make any difference.” [M02]

In this example, the community member used both informal and formal appeals to the local government, leveraging his position as a constituent and member of the community to attempt to gain access to sanitation services and indirect control of mosquito populations. In contrast, identical appeals, specifically an arzi, were cited as effective ways to request change in the water provision system from the panchayat. Because these mechanisms of access are context dependent, a household that has access to water may not have access to the services and provisions needed to control mosquito populations around their house.

Unlike the water governance system, which satisfactorily provided water to nearly all participants, over half of the participants (12/21) were concerned about mosquito control in Sarjapur. Of those not concerned about mosquitoes (9/21), four participants lived in private developments with frequent insecticidal fogging programs. Community members recognized the widespread prevalence of mosquitoes, stating that "it's not just in [our neighborhood], every other place has mosquitoes" [WM01], and did not identify spatial inequalities in mosquito burdens in their narratives. Similarly, our entomological surveys revealed few consistent differences across sites and land types (Table 1). Mosquito abundance was very heterogeneous across Sarjapur, ranging from 0 – 1912 mosquitoes per trap night. The majority of mosquitoes (95.8%) caught were *Culex quinquefasciatus*, which are known to be preferentially caught by CO_2-baited CDC light traps (Sriwichai et al. 2015), while 1.9% were *Aedes* species, including *Ae. aegypti* and *Ae. albopictus*. Mosquito abundance was highest at colony sites, although variation was very high (mean ± *sd* = 152.75 ± 232.28). Town and village sites, which both had traditional housing types but differed in impervious surface values, had lower mosquito abundances, with mean abundances of 53 ± 38.13 *sd* and 85.45 ± 90.18 *sd*, respectively. The primary differences that we found regarding water access, private vs. public water provision and the presence of a household sump-OHT system, were not associated with differences in mosquito abundances in our entomological sampling. We caught an average of 72.1 ± 55.6 *sd* mosquitoes in neighborhoods that relied on public water and an average of 130 ± 122 *sd* mosquitoes in neighborhoods that relied on private water. Similarly, neighborhoods where all households had access to an individual or communal sump had an average of 131 ± 114 *sd* mosquitoes, while neighborhoods with some or no sumps had an average of 82.4 ± 83.1 *sd* and 59.5 ± 11.5 *sd* mosquitoes, respectively. In the mapping exercises, community members identified sources of mosquitoes spread across their neighborhood, particularly near vegetation, and highlighted how mosquitoes from nearby sources easily spread across space.

In addition to differences in measured mosquito abundances across sites, participants expressed differences in their perceptions of mosquito abundances. These perceptions were associated with participants' feelings of vulnerability, particularly participants' ability to mitigate exposure to mosquitoes in outdoor spaces where mosquitoes were present. In general, those households without sump-OHT systems performed more domestic tasks outdoors and moved through vegetated spaces they identified as mosquito habitat during their everyday routines. As such, they had limited ability to avoid spaces perceived as having high mosquito exposure compared to those participants who used these areas primarily for leisure or recreation. An in-depth comparison of ecological measures of mosquito abundance and individuals' everyday experience with mosquitoes in Sarjapur is explored further in Author (2022).

DISCUSSION

Our study highlights the contrast between the everyday governance of water and the everyday governance of mosquitoes and found that the effectiveness of specific everyday governance practices is context dependent. Community members relied on both public and private mechanisms to access water satisfactorily, but were not able to apply these mechanisms to the control of mosquitoes. Economic capital was used to implement both water and vector control practices. While economic capital resulted in water access systems that met residents needs of frequency and quality, economic capital applied to vector control (in the form of private insecticide companies) was not related to trends in mosquito abundances. In contrast, practices that relied on social capital, or a more nuanced combination of practices, could be used to implement water access practices, but not vector control practices. Currently, vector control practices are only accessible via economic capital, and, even when implemented, have mixed effectiveness. In the context of increasing water stress and the high risk of mosquito-borne disease in this area, context-dependent governance outcomes that consider wealth or social capital should be considered when trying to identify populations at increased risk of mosquito-borne disease.

While both water and mosquito control contribute to the health and well-being of an individual, mosquito control is emblematic of the modern public health approaches associated with neoliberal policies, in which disease risk is determined by individual behavior, not social determinants, and the responsibility of prevention lies with the individual, not the state (Petersen 2002, Levy 2019, Navarro 2020). Global health narratives often emphasize individual, rather than municipal, responsibility for vector control efforts (Robbins et al. 2008, Kelly and Lezaun 2013, vonHedemann et al. 2017, Butterworth 2020) and this narrative was employed by one panchayat chairman:

> "There's nothing really that can be done about mosquitoes. They're not under our control. We can clean one house, but another house might not be clean...Here and there, they keep throwing garbage. From the panchayat side, we have given them buckets to put their garbage in. We have our tractor, put it in that." [KS01]

In this narrative, the panchayat claims to fulfill their responsibility by providing solid waste pick-up and it is due to the "unclean behavior" of individuals that mosquitoes persist. This is not hidden from those who have been blamed, with one community member noting the irony of this responsibility given her lack of control over the frequency of water provision:

> "There is no such support. All they [the panchayat] do is tell us not to stock water and things like that, but what can we do, we have to keep stock because they release water just once a week." [L01]

Interestingly, individuals held multiple beliefs regarding who was to blame for vector control that reflected the duality of public health narratives. They pointed out that other members of the public, "they", initially created mosquito habitat through 'unclean' practices and mismanagement of their surrounding environment. In this way, community members also placed the responsibility for vector control on the individual. This has been seen elsewhere, driven by a variety of mechanisms: perception of mosquitoes as not a "serious health problem" that requires government intervention (vonHedemann et al. 2017), a distrust or disillusionment with government action (Harris and Carter 2019), and the rise of medical populists that performatively blame marginal communities (Lasco and Gregory Yu 2022). Yet, participants continued to frame the government as responsible for providing the services and technologies (e.g., solid waste disposal, larvicide, fogging) to control mosquito populations. If vector control serves as the tool of the state, the inability of the state to control a mosquito outbreak can also be a sign of its failure to meet its responsibilities (Addlakha 2001). While citing the lack of government support, participants simultaneously attempted to hold the government accountable for not fulfilling its "duty". This differed from participants' views of water access, where the government was framed as responsible for providing water to households, but the technology to store water via sump-OHT systems was viewed as a household responsibility. No participants requested that the government provide the means to store water in their household, rather they requested more frequent and reliable water provision to meet their existing storage capacity. When the government did not meet these needs, community members with the requisite economic capital turned to private sources such as boreholes or tankers to access water for their household. For water access, there seems to exist a clearer delineation between the responsibilities of households and the responsibilities of residential associations or local governments, and, notably, there is consensus about this division among all actors.

This household-based approach to vector control was ineffective at controlling mosquito populations in Sarjapur, as evidenced by narratives from the panchayat and community members and our own entomological surveys. Even those households that were able to implement private vector control via economic capital had high abundances of mosquitoes. This may be due a scale mismatch between the boundaries of responsibility placed by governance narratives and the ecological boundaries of mosquitoes. . Unlike municipal water, which can be privatized and supplemented via private water sources, mosquitoes are not contained by property boundaries and their abundance is determined by a variety of ecological processes, such as habitat availability, microclimate, and host abundances (LaDeau et al. 2015). Vector control practices often target larval habitat at the household-level, rather than considering structural inequalities perpetuated by state policies at larger spatial and political scales (Rodríguez-Díaz et al. 2017). The ubiquity of mosquitoes in our study suggests that practices enacted at the level of the household, either by the state or private owners, are ineffective at controlling mosquitoes on a larger spatial scale. For example, one housing colony conducted weekly insecticidal fogging, but reported the third highest abundance of mosquitoes among our sites. A participant's sketch map identified a neighboring vegetated area used for unregulated solid waste dumping as a suspected source of the insects. In this instance, vector control applied at the scale of the neighborhood (fogging) was ineffective against the coarse-scale ecological dynamics (landcover patterns) driving mosquito populations. Note that this does not mean that vertically-structured, mass government-led campaigns are necessarily the most effective approach. In fact, there are many examples of unsuccessful vector control campaigns led by governments or international organizations at large-scales (Litsios 2015, Graboyes and Meta 2022). Rather, we wish to draw attention to the disconnect between states holding individuals accountable for their risk of mosquito-borne disease via governance of the local environment and the much larger spatial scale at which the ecological dynamics of mosquitoes and mosquito-borne disease are occurring. Governance enacted at the individual-level, without some form of coordinated action, will likely be ineffective at controlling mosquito populations, which are influenced by hydrological and climatic processes happening at city-scales. While research on the effectiveness of vector control programs on dengue disease risk is rare, this agrees with a meta-analysis that found community-based, and not household-based, practices were associated with reduced dengue disease incidence (Bowman et al. 2016).

Aggravating the problem of spatial scale mis-match between individual responsibility and ecological processes was the lack of effective governance mechanisms by which community members could access vector control and advocate for city-wide programs. The global health narrative of individual responsibility espoused by government officials and internalized by residents prevented community members from holding their government accountable for mosquito-borne disease prevention in the same way that they did for water access. Everyday governance of both water access and mosquito control bear signs of influence of global narratives of rights and responsibilities concerning each environmental amenity. However, while the narrative of water as a right helped community members negotiate with the panchayat for water access, the narrative of health as an individual responsibility was an obstacle to requesting local government intervention. Indeed, members of Sarjapur were unable to leverage their identity as citizens to advocate for additional vector control, limiting their ability to govern the surrounding ecosystem outside of private and domestic spaces.

Neither narrative is unavoidably hegemonic, and there are many other global narratives that combine to influence everyday practices within the local context. For example, related narratives of water access involve water privatization or commodification, often falsely described as an opposing binary to water as a human right (Bakker 2007). Private water provision, either via borehole or tanker delivery, was also a common water access practice in Sarjapur, and, in this context, did follow a similar commodification binary because public water was provided free of charge. In nearby towns that fall within the boundaries of the Bengaluru metropolitan area, and therefore are managed by the Bruhat Bengaluru Mahanagara Palike and the associated Bangalore Water Supply and Sewerage Board, municipal water was not free of charge and households paid for connections as well as monthly water use. In Sarjapur, only those living in privately-managed colonies relied primarily on private water sources, opting-out of the political proletariat through their economic capital (Gopakumar 2009). In fact, one resident joked that, although they pay taxes, panchayat water is not provided to their colony. On the other hand, free panchayat-provided water helped in strengthening the social relationship between politicians and constituents through the exchange of water access and political support. Indeed, one participant referred to the chair of the panchayat, the *sarpanch*, as the "father of the village" [T01] , and described a relationship resembling political patronage, as has been seen elsewhere in Bengaluru in relation to water provision (Srihari Hulikal Muralidhar 2014). In this local context, there was little support for adopting commodification of water narratives, because the current form of everyday governance, and the global narratives it champions, serves both community members and elected officials.

This study focused on one aspect of urbanization, water access practices, and its association with mosquito dynamics in Sarjapur. We did not find a relationship between different water access practices, namely private vs. public water and the installation of an OHT-sump system, and mosquito abundance. In addition, residents did not name household water storage systems as a source of mosquitoes, despite this narrative being promoted by local authorities. Rather, participants identified the city-scale process of land-use change associated with urbanization as a potential driver of mosquito abundance. Land-use change created spatial patterns in both the physical landscape and the everyday governance of the landscape, creating a matrix of patches along gradients of rural to urban ecologies and private to public management regimes. Spatial patterns in landcover can structure spatial patterns in mosquito populations in cities, particularly the presence of vegetated areas or wetlands, which serve as mosquito habitat (Brown et al. 2008, Claflin and

Webb 2016), nearby residential areas. In addition, we found that spatial patterns in governance for these spaces can mediate these environmental effects. The fragmented development pattern seen in the periphery of Bengaluru (Nagendra et al. 2012) has lead to areas with combinations of suitable biophysical habitat and failures in everyday governance that limit individuals' access to mosquito-free space.

CONCLUSION

Faced with the urbanization of Bengaluru and the development of two large SEZs within its municipal limits, Sarjapur is changing rapidly. New industry and developments will bring more private developments and apartment complexes, and some community members hope it will bring new infrastructure. However, expansion of the piped infrastructure will continue to ignore those without sump systems, especially as higher pressure on existing boreholes results in less frequent water provisions. Rather than relying on a binary “connected vs. not connected” approach to water access (Jaglin 2004), our findings suggest a better approach may be to address inequality in water access among households by considering the whole water system, particularly individual storage capacity. Currently, households without water storage systems rely on their relationships with panchayat members and positionalities as members of the community the panchayat serves to access water. Water is provided at no cost via municipal pipes. However, if this changes to a cost recovery model, as has been encouraged by parallel global and national water policies (Mukherjee et al. 2015), economic capital risks becoming necessary to access water, with negative consequences for households that lack this form of capital.

In contrast, vector control is influenced by individualized health narratives that focus on private vector control practices and is inadequate to control mosquito populations in Sarjapur, as evidenced by entomological surveys and participant responses. In the existing governance system, even those households with the economic capital needed to pay for private vector control had similar mosquito burdens as those without access to local vector control. Sarjapur’s unique urban matrix, with patches of rural land directly abutting recently urbanized residential areas, further complicates vector control by creating many individual patches where mosquitoes may breed. Unlike water access, which is determined at a household level, mosquito populations are influenced by the surrounding environment and can move up to several kilometers, depending on the species. Residential areas in Sarjapur are situated within a variety of surrounding landcovers, such as a colony abutting a low-laying swamp that holds water during monsoon season or a village next to a fully-paved industrial center. Nearby landcover influences mosquito populations by providing adult and larval habitat (Brown et al. 2008, Claflin and Webb 2016), but falls outside of individuals' control in Sarjapur, particularly as landcover changes rapidly with urban development. Shifting the responsibility for vector-borne disease control away from an household-based responsibility narrative to a rights-based narrative, like the dominating narrative regarding “rights to water” (Mehta 2005), could help residents negotiate for access to vector control. In addition, removing the focus on individual responsibility and acknowledging processes occurring at the city scale could allow for city-wide, community-based vector control programs, which have been successful in reducing mosquito-borne disease in other urban centers (Fillinger et al. 2008, Geissbühler et al. 2009).

Like systems of water governance, an effective vector control program that reduces risks to human health should not be simplified into binaries of state vs. individual or public vs. private, but rather could imagine alternative, hybrid approaches (Bakker 2007). Studies of mosquito "self-governance" in the southwest United States revealed similarly complicated views of community members of public vs. private responsibility of vector control, and that the management approach differed according to local context (Robbins et al. 2008, vonHedemann et al. 2017). A combination of interventions that address fine-scale mosquito habitat within a household and landscape-scale ecological and hydrological dynamics via both individual and municipal governance systems may be more ecologically effective. In addition, this could simultaneously establish a pathway by which community members can hold the local government accountable for mosquito-borne disease, their expressed preference.

The motivation for this study was the increasing incidence of dengue in Bengaluru. Mosquito-borne disease, particularly dengue, is often considered a disease of poverty, a result of higher water insecurity in households without economic capital (Adams et al. 2020). Recently, this connection between poverty and mosquito-borne diseases has been questioned (Mulligan et al. 2015), and the lack of consideration of vector control in urban governance and planning has led to high dengue incidence rates in "elite", "modern" cities (Mulligan et al. 2012). Due to the species identity of mosquitoes in our entomological surveys, our results do not apply specifically to dengue, but vector control more broadly. Similar to dengue-specific studies, we also found the equivalence of high mosquito burdens as a "symptom of poverty" to oversimplify the everyday processes of governance that vary as a function of more than just household wealth. . Our study considered processes of governance in urban systems, but from an everyday, household perspective, and noted the difficulty households faced in requesting vector control and holding the local government accountable, a failure in the system of governance at a micro-level. Our entomological samples were dominated by *Culex* mosquitoes, which are not a primary vector of dengue, and we focused on vector control broadly, rather than species-specific interventions such as the release of sterile insects. While it is possible that everyday governance could differ specifically for *Aedes* mosquitoes, this was not mentioned by participants and only species-indiscriminate vector control (e.g. fogging, larvicide, drain cleaning) was available in Sarjapur. Importantly, our study was limited in that we did not consider transmission of the pathogen itself and associated health outcomes, which have been found to differ across socio-demographic markers of economic position (Power et al. 2022). Expanding the consideration of household governance of mosquito-borne disease to also include individual differences in access to health institutions and treatment is a logical, though increasingly complex, next step of this work.

Finally, this study contributes to the recent but growing body of work exploring the nuanced ways in which people access the state in urbanizing areas via everyday governance (Anand 2011, Wamuchiru 2017, Lawhon et al. 2018, Truelove 2020) by expanding these theories to the management of mosquito-borne disease. Prior work on the governance of mosquito-borne disease has focused on state actor and institutions (e.g., Shaw et al. 2010, Mulligan et al. 2012). As studies of the urban political ecology and governance of water draw on feminist approaches to consider everyday practices, relationships, and micropolitics in relation to water access (Truelove 2011), we demonstrate the utility in employing an everyday perspective in the consideration of vector control access. Metrics and quantification are becoming increasingly valued in public health (Hoeyer et al. 2019). Everyday narratives ensure the messy, embodied, human side of mosquito-borne disease management is not forgotten.

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