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RESEARCH PAPER

The Political Ecology of Rural Community Ponds in Kerala, India: A Quantitative Study

Vinay Sankar*

Abstract: Inequities in access to water across economic classes and social groups have been aggravated by the commodification of ecosystems. Institutional governance of small freshwater bodies, like ponds, is under tremendous stress and often cannot cope with increasing pressures from market forces and state interventions. Recently conceptualized as a "composite resource", ponds are vital entities in the ecological, economic, and socio-political landscape. The central objective of this study is to understand the access and utilization patterns of rural community ponds in Kerala, India, by employing a survey method. I attempt to integrate the literature on commons and political ecology, review the institutional arrangements governing rural public ponds, assess their ecological health, and situate the empirical evidence in a theoretical framework of the commons. I find universal access to these water bodies, which cuts across social and economic groups, for domestic uses such as drinking, bathing, washing, and cleaning; this utilization has a class and gender dimension. A majority of the surveyed ponds showed signs of robust ecological health in terms of total dissolved solids and pH values, functional embankments, and the absence of any polluting economic activity in their vicinity. I also find that factors such as institutional arrangements, the ecological integrity of community ponds, and the extent of diversification of water sources determine how the pond is utilized for various domestic purposes.

Keywords: Political ecology; commons; rural ponds; countermovement; panchayats; Kerala

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* Department of Humanities and Social Sciences, Birla Institute of Technology and Science (BITS), Pilani, Hyderabad Campus. Jawahar Nagar, Kapra Mandal, Medchal District - 500078, Telangana, India. vinay.sankar@gmail.com

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1. INTRODUCTION

Small freshwater bodies like ponds play a vital role in water provisioning, especially for the poor (Cornea, Zimmer, and Véron 2016). In the urban context, ponds have been recently conceptualized as a "composite resource" made of water (for various domestic purposes like bathing, washing, and cleaning, as well as for livelihoods like fish rearing); land (for reclamation later); and common space (for recreation and social gathering) (Zimmer, Véron and Cornea 2020). At this scale, ponds follow the characteristics of commons with their associated properties of rivalry and excludability.

Traditional commons, such as forests, water bodies, pasture lands, and fisheries, are critical resources or infrastructure sustaining millions of lives and livelihoods worldwide, especially for the income poor (Jodha 1986). Commons or common pool resources (CPRs) are defined as a "natural or man-made resource system that is sufficiently large to make it costly to exclude potential beneficiaries from obtaining benefits from its use" (Ostrom 1990, 30). CPRs are broadly considered resources accessible to the whole community over which no individual has exclusive property rights (Jodha 1986). Thus, small freshwater bodies, such as lakes and ponds, are vital entities in the ecological, economic, and sociopolitical landscape.

Despite their vital importance, ponds and lakes continue to be vulnerable to destruction and degradation. Zimmer, Véron, and Cornea (2020) state that the destruction, degradation, and restoration of ponds are not merely biophysical processes but ones that signify sociopolitical and institutional changes. Institutions are conceived as the "rules of the game" (North 1990) or as "prescriptions for organising structured interactions" (Ostrom 2005) while being essentially "distributional mechanisms that are power-laden" (Mahoney and Thelen 2010). The problem is that the institutional governance of small freshwater bodies is under tremendous stress and often fails to cope with increasing pressures from market forces and state interventions (Nayak and Berkes 2011; Unnikrishnan, Manjunatha, and Nagendra 2016; Nayak, Oliveira, and Berkes 2014; Bharucha 2018).

Studies on India's lakes and ponds have so far been confined to either large cities like Bengaluru (Unnikrishnan, Manjunatha, and Nagendra 2016; D'Souza and Nagendra 2011), Hyderabad (Mariganti 2011), and Kolkata (Bose 2015), or to small towns like Bardhaman in West Bengal (Cornea, Zimmer, and Véron 2016) and Navsari in Gujarat (Zimmer, Véron, and Cornea 2020). The status of India's village ponds is largely understudied.

Therefore, in this study, I aim to identify the patterns of relationships between rural ponds held in common and proximate communities. I attempt to understand how the politics of water in terms of access and utilization patterns impact social equity and ecological integrity. In this regard, I address the following questions:

1. What is the relationship between rural community ponds and proximate communities—who has access and for what purposes?
2. What is the ecological health status of rural ponds in the study area?
3. What is the institutional arrangement governing them?
4. How can we theoretically situate these small freshwater bodies from a commons perspective?

We also seek to find the conditions under which various social groups and communities have the "ability" to access and utilize the rural pond waters. Access has been defined as the "ability to benefit" without solely focusing on property rights (Ribot and Peluso 2003). Schlager and Ostrom (1992) define access as the right to enter a specified physical property. Utilization or withdrawal is the right to obtain products such as water, fodder, and fish. They consider rights to be actions that are authorized and rules as prescriptions creating that authorization.

Ostrom (2005) theorized that for collective action and community governance of natural resources, the collective benefits should be higher than the collective costs. However, as I argue in this study, the critical question is whose costs and benefits matter in the institutionalized collective action. Nonetheless, Ostrom's empirical work disproved a widespread belief that commons invariably led to destruction. She demonstrates that common property management by the users themselves could lead to democratic and ecological governance beyond markets and states (Ostrom 2010). Nevertheless, the question here is: why go beyond the state? Why can the state not be a part of the commons arrangement? As Peter (2021) argues, access to vital goods and resources should be provided by the state, and that state should support commons and commoning. He maintains that while "commons is an alternative to democratic capitalism, this alternative does not exist beyond markets and states and instead lies in transforming these institutions through commons and commoning" (Peter 2021, 30). In the case of rural ponds in the study site in Kerala, the state plays a pivotal role in the institutionalization of community resource governance.

The literature is divided on the role of the state in the process of "socio-physical constructions of hydraulic environments" (Swyngedouw 2009). Birkenholtz (2016) and Snorek, Moser, and Renaud (2017) argue that the state often abdicates its solemn responsibility to uphold traditional rights and sometimes intervenes to the detriment of collective rights. However, Mansbridge (2014) and Ramachandraiah (2001) posit that the state has a role in governing the commons. Mansbridge (2014) argues that there is a vital need to build an institutional structure incorporating the role of the state along with grounded local knowledge. Ramachandraiah (2001) contends that judicial interventions at the highest level, which safeguard fundamental rights related to safe drinking water, would improve the general confidence in institutions.

Though the institutional approach to analysing common property management is useful in tracing out the rules and norms involved, it has been critiqued for not considering aspects of power and political economy (Agrawal 2007). Vos *et al.* (2020) state that the Ostromian conceptual frameworks, like Institutional Analysis and Design and Social and Ecological Systems, fail to highlight the political dimensions of common pool resources and underlying social movements. However, political ecology perspectives provide a powerful lens to analyse the role of the state and markets in community natural resource governance (Osborne 2015). Following Agrawal (2007), I attempt to integrate the literature on commons and political ecology.

Political ecology helps us to examine the relationship between economics, politics, and nature by critically situating issues in a historical and contextual setting (Robbins 2012). It interrogates how political, social, and economic factors impact nature or the environment at different scales—like local, regional, and global—by examining environmental problems, concepts, and actors (Bryant and Bailey 2005). For example, a political-ecological view of water considers a "close correlation" between hydrological cycle changes at the local, regional, and global scales and political, social, and economic power relations (Swyngedouw 2009). Swyngedouw asserts that "hydraulic environments are socio-physical constructions that are actively and historically produced" (Swyngedouw 2009, 56). A political ecology perspective of water uses the lens of power to analyse the intersection of water, infrastructure, and political rule to identify whose decision-making shapes water systems with due consideration to the history, culture, and socioeconomic practices of the context under study (Boelens 2014). It engages with the literature on the commodification and neoliberalization of nature by attending to the biophysical nature of resources and power relations (Osborne 2015).

Polanyi (2001), elaborating on the commodification of nature, terms nature as a fictitious commodity to underscore the fact that nature is not a commodity produced for markets. To Polanyi, production is the "interaction of man and nature", and binding them to the vagaries of supply and demand is akin to commodification. "Countermovement" is essentially a movement towards decommodification (Kentikelenis 2017). The commodification of ecosystems such as forests and water, using various "valuation" techniques, has not led to better, more equitable governance systems (Heynen and Robbins 2005).

Kentikelenis (2017) finds that countermovements are usually manifestations at the macro or national level to achieve the end goal of decommodification. However, he argues that local-level countermovements attempting to protect livelihoods from the assault of state and market forces demand attention. Micro foundations based on the community's material, political, and sociocultural factors are significant in forming a countermovement (Kentikelenis 2017). Attempts to commodify nature would often create a countermovement to protect the commons from getting trapped in the logic of the market (Kallis, Gómez-Baggethun, and Zografos 2013). Especially in the case of elements, like water, with its nature of "fluidity, continuity and temporal variability", commodification is harder (Bakker 2005).

Nayak and Berkes (2011), Unnikrishnan, Manjunatha, and Nagendra (2016), Nayak, Oliveira, and Berkes (2014), Bharucha (2018), and others who studied commons such as lakes and small-scale fisheries have found the lack of recognition of traditional community rights to be a significant issue. It has led to exclusion, conflict, degradation, and even the disappearance of such systems, and marginalization and poverty among dependent communities. They are emphatic about situating a case in its historical context to understand the contemporary picture of the commons ecosystem. Agrawal (2014) also maintains that future research strands on the commons need a more historical, reflective, and critical look. This study is an attempt in this direction.

Building on the theoretical framework of the commons (Ostrom 2009) and the conceptual framework of the countermovement (Polanyi 2001), I attempt to identify the patterns of relationship between small freshwater bodies, such as rural community ponds, and proximate communities. The study draws inspiration from a series of path-breaking and seminal works, from Jodha (1989)—who used marginal analysis (bi-variate tables and the linear regression technique) to verify the broad trends associated with the access and utilization patterns of CPRs in India—to Agarwal (2010), who analysed the political economy of women's presence in community forestry using linear and logistic regression tools. Similarly, in this study, I employ quantitative analysis as a tool to identify the patterns of relationship between the pond commons and its users.

Moreover, I attempt to contribute to recent trends in the literature (Kashwan 2016; Bennett et al. 2018), which bring together two diverse conceptualizations of power and institutions to understand how they shape each other. I aim to build on the institutional analysis by Ostrom and others by contextualizing institutions in the micro-level power structures of caste, class, and gender.

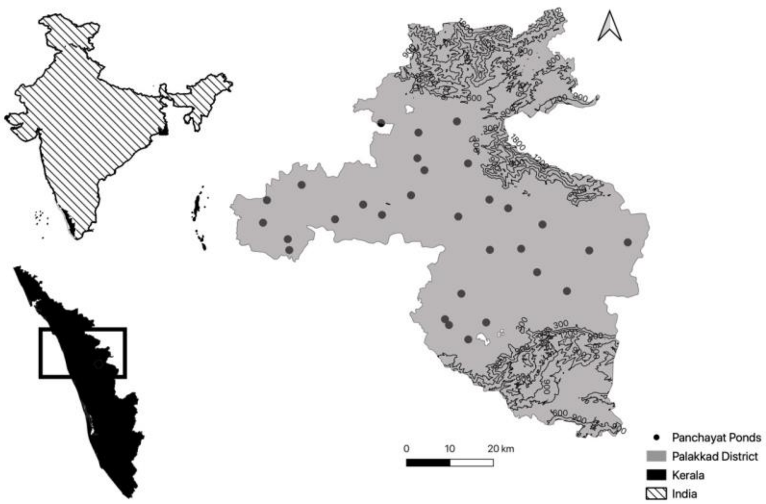
2. RESEARCH CONTEXT

I conducted the research in Kerala, as it is well known for undertaking reforms in water, land, and local democracy. As Krishnan and George (2009) note in their study on irrigation tanks in Kerala's Palakkad district, small freshwater bodies like ponds and larger structures like tanks were impacted by reforms in land and local self-governments (panchayats). The rural public ponds in Kerala are the creation of a set of reforms, starting from the land reforms of the 1950s and 1960s to the reforms in decentralized democracy, which began in the 1990s. Many private ponds became public ponds through the land reforms, as land ceiling restrictions forced the landed gentry to let go of these water bodies and place them under state control. Various water policies at the national and provincial levels have had implications for how communities treat water. The Kerala State Water Policy (2008) states, "water is not a commodity and it is part of an ecosystem for the benefit of all". Similarly, the devolution of powers to the local self-government is understood to have a substantial impact on local water commons. The political and historical context of Kerala, which has shaped the governance of rural ponds, makes it a relevant and important field site.

In the context of southern India, commons are known as *poramboke*—a term for lands reserved for public purposes or communal use in villages, as per Section 4, the Kerala Land Conservancy Act, 1957 (Department of Revenue 1957). In the official land revenue records, such common lands are classified as "wastelands" (Jodha 2000). An elementary examination of the revenue classification of "common land" in Kerala reveals that entities such as "*thodu (*irrigation channels), *kulam* (pond), river, bund, *kayal* (backwaters), sea, road, *kavu* (sacred grove), or accreted/unsurveyed land is considered *porumboke*" (Foundation for Ecological Security 2014, 16). In the case of Kerala, the Kerala Panchayat Raj Act, 1994, ensured that local self-governments are vested with considerable powers concerning the governance of water resources.

I conducted this study in the district of Palakkad in Central Kerala, as when it comes to the total number of public ponds or reservoirs, Palakkad has the highest number—close to a one-third share in the state (Government of Kerala 2019). As per the *Panchayat Level Statistics*, prepared by the Department of Economics and Statistics, Government of Kerala, there are 854 panchayat ponds and 88 gram panchayats (GPs) in Palakkad district (Government of Kerala 2019). I identified 30 panchayat ponds using a multi-stage sampling method (Figure 1) (Table 10).

Figure 1: The Location of Surveyed Panchayat Ponds in Palakkad, Kerala, India



Source: C S Saneesh, Helmholtz Centre for Environmental Research – UFZ

Apart from identifying the access and utilization patterns of rural ponds, I intend to identify the institutional arrangement over these ponds: the rules of use and the process of framing them, the social and economic background of the proximate households, and the ecological health indicators of the ponds.

3. MATERIALS AND METHODS

3.1 Data Collection

I formulated a multi-stage sampling procedure to identify the final set of panchayat ponds to be surveyed. Out of the 14 districts in Kerala, I deliberately selected Palakkad district at first, as it has the highest number of public ponds in Kerala (Government of Kerala 2019). Secondly, from each of the panchayat blocks (except Attappady, a high-altitude block having an insignificant number of panchayat ponds), I chose the panchayats with the highest number of ponds. A few panchayats I chose in the original sample had been transformed into municipal areas. In such cases, I selected the nearest gram panchayat to ensure sample spread. Finally, from each of those panchayats, I selected one survey pond randomly. I generated a list of common ponds in each of the chosen panchayats using a participatory appraisal method. The data available on community ponds at the district and panchayat levels had discrepancies in numbers, names, and location. Finding the exact location of the community pond was possible only through a participatory appraisal with the user community. Using a lottery method, I selected a pond randomly from the list generated after the participatory appraisal. I chose households for the survey randomly within the panchayat ward of the pond. From the pilot study, it was evident that a majority of the users of the pond lived in the same ward as the pond.

The survey instruments used for this study are a household-level survey questionnaire and an observation schedule at the pondscape level. I administered a structured, coded questionnaire to a self-identified decision-maker of the household. The questions were focused on the social and demographic characteristics of the decision-maker, the access and utilization patterns of panchayat ponds, and institutional governance over such common ponds. Before the actual survey, the questionnaire was translated into the local language of Malayalam. It was then tested for its relevance and clarity in the district of Thrissur, adjacent to the district of Palakkad. I surveyed 121 households living in the proximity of 30 panchayat ponds across the district of Palakkad.

3.2 Demographic Characteristics

Out of the 121 survey respondents, 63 were female, and 58 were male, a near equal distribution, which enabled a gendered analysis of access and utilization patterns (Table 11). The sample population I studied shows a distribution of 84%, 12%, and 4% for Hindus, Muslims, and Christians. According to the Directorate of Census Operations, Government of Kerala (2014), Hindus constitute 67% of the population in Palakkad district, followed by 29% Muslims and 4% Christians. According to the 2011 Census of India, the state's population comprises 54.73% Hindus, 26.56% Muslims, and 18.38% Christians. Since my fieldwork from December 2019 to February 2020 coincided with a major resistance movement against a discriminatory citizenship law—the Citizenship Amendment Act, 2019—brought in by the Government of India, quite a few minority households were reluctant to participate in the survey.

Caste-wise, more than half of the respondents (53%) belonged to the Other Backward Classes (OBC) category. OBCs form the majority of India's marginalized population. Close to 50% of the respondents had daily wages as their primary source of income. Approximately 60% of the respondents belonged to the priority and high-priority section in the Public Distribution System (PDS) of the Government of Kerala. The economic category that the respondent's PDS card indicates is a robust representation of the economic class of the respondent households. I found that 78% of the priority PDS cardholders were landless, and as much as 69% of them were daily wage earners; 64% of the total number of households were landless as well.

3.3 Indicators of Institutional and Ecosystem Health

In their study to understand the link between collective action and forest management efforts, Chakrabarti et al. (2001) developed an index using a set of 18 forest management activities, such as planting, harvesting, and marketing. A group earns 0.5 points for the adoption of each management activity, and the actual implementation of collective rules earns one point per activity. On similar lines, I attempted to construct composite scores related to the ecological health of the pond and the collective action around it.

Based on field observation, I factored seven social and ecological health indicators to create a composite ecological score (CES) for each of the 30 surveyed ponds. They are the presence of aquatic weeds (mostly *Salvinia molesta* in the present case); evidence of minor erosion; recreational usage; evidence of open defecation; the presence of polluting economic activity near the surveyed pond; and the total dissolved solids (TDS) levels and pH levels of the pond waters (Kumar and Padhy 2015). I conducted a chemical analysis recording the pH and TDS levels of each of the community ponds using portable, digital pH and TDS meters in January and February 2020. The ponds were awarded one point each for the absence of aquatic weeds, absence of erosion (indicating a functional embankment protecting the pond), usage for recreational purposes, lack of signs of open defecation, and absence of polluting economic activity (such as brick kilns) in the pond vicinity. I assigned ponds zero points for the presence of contaminating agents and lack of recreational usage. Apart from these five indicators, I ranked the panchayat ponds based on the TDS and pH levels, which show the chemical composition of the pond waters. Clean, potable water would have a TDS value of less than 300 ppm (World Health Organization 2003, 1) and a pH of 7. Having clean water improves the chances of the utilization of the pond for a variety of purposes. As the mean TDS level for the 30 ponds was 103 (Table 1), I gave all ponds that scored less than 103 one point, and the others scored zero. Similarly, ponds having pH levels ranging from 6.5 to 7.5 (7 being the ideal pH level and 0.5 the sample variance) were assigned one point and the others, zero.

Table 1: Select Determinants of Ecological Health of the Ponds

S.No	Indicators of the ecological health of ponds	Number of ponds	Percentage of ponds
1	Absence of erosion of the pond bank/presence of embankments	20	67
2	Absence of aquatic weeds in the pond	11	37
3	Absence of open defecation in the vicinity of the pond	28	93
4	Absence of polluting economic activity in the vicinity of the pond	22	73
5	Use for recreational purposes such as swimming	23	77
6	TDS levels less than 103 ppm (mean level among 30 ponds)	22	73
7	pH levels between 6.5 and 7.5	14	47

Note: Percentages are based on the denominator of N = 30
Source: Field observation by the author; TDS and pH levels measured using electronic meters.

I gave panchayat ponds scoring a maximum of seven points a composite score of 100. Two surveyed ponds, one in Koppam and another in Karimpuzha, scored a cent percentile. Ponds scoring a six out of seven scored a total of 86. Seven ponds scored an 86. Six ponds held the third-highest score, 71, for having scored five points out of a possible seven. The mean score of the 30 ponds was 65.19, and only three ponds scored less than 30.

The next step was to compute a composite institutional score (CIS) to capture the importance of the organizational aspects of pond systems. The primary focus of this study was public ponds under the custodianship of local panchayats. Local panchayats in Kerala have a high level of discretionary power and accountability toward citizens (Venugopal and Yilmaz 2009). The panchayats in Kerala were entrusted with the power to manage water bodies within their jurisdiction under the Kerala Panchayati Raj Act, 1994. I tried to quantify the aspect of collective action in and around the surveyed panchayat ponds. The institutional score was primarily based on Ostromian design principles (Ostrom 1990). I asked the respondents if there are specific rules for the access and extraction of water and what the role of the gram panchayat is in formulating access and utilization rules, monitoring, sanctioning and conflict resolution, and participation in deliberations on panchayat ponds.

Table 2: Select Determinants of Collective Action

S.No	Factors of institutional strength	Number of respondents that answered in the affirmative
1	Existence of rules for extraction of pond waters	115 (95%)
2	GP has a role in framing access rules	117 (97%)
3	GP has a role in framing usage rules	116 (96%)
4	GP ensures non-violation of the above rules	117 (97%)
5	GP able to punish rule violation	121 (100%)
6	GP has a role in conflict resolution	115 (95%)
7	GP is the significant place of discussion on ponds	114 (94%)
8	Respondent attends discussions on ponds in GP	100 (83%)
9	Respondent speaks in such discussions in GP	90 (74%)
10	User communities are the major beneficiaries of pond	117 (97%)

Note: Percentages in parenthesis have a common denominator of N = 121
Source: Field survey by the author

I assigned the 11 gram panchayats who scored a perfect 10 a composite score of 100. Thirteen panchayats scored 90 or above, and the mean score of all panchayats was close to 93. To capture elements of a potential countermovement (Polanyi 2001), I also asked specific questions related to resistance to unsustainable or unjust usage of the pond (such as commercial-scale fish rearing in public ponds, diversion of pond waters for major irrigation, and dumping of waste) through deliberations in the panchayat. While in 24 panchayats out of the 30 surveyed, respondents did not recall any incidents of resistance to an adverse rule change in the recent past, 14 respondents belonging to six panchayats mentioned how they had pushed back unsustainable or inequitable usage of ponds through formal protests in the panchayat. Except for one, these 14 respondents were Dalit Bahujans from the SC or OBC categories.

Finally, I calculated a diversification score called the Composite Diversification Score (CDS), which indicates the extent to which households were diversified with respect to access to various water sources for domestic purposes (Table 3). While developing an urban water security indicator, Jensen and Huijuan (2018) included a diversity indicator based on the contribution of alternative sources along with the major source of water supply. I developed the CDS along those lines. If a respondent has multiple sources for any usage or purpose, I assign them one point, and if they have only one, I give them zero. The aggregate diversification score is computed by adding the individual scores for drinking, cooking, bathing, washing, and cleaning. Therefore, if a respondent has diversified sources (two or more) for all the purposes, they score a cent percentile. Nine such respondents (7%) had total and complete diversification. Thirty respondents (25%) had zero diversification, as they only had a single source for each of the usages. They are mostly landless daily wage earners, owning just their homestead plots. A low overall CDS (the mean CDS is 37.52) shows the relative scarcity of water in the region (Table 3). CDS could also be considered an intervening variable between CIS and CES in the present context.

Table 3: Number of Households having Diversified Water Sources for Various Usages

Drinking diversification	Cooking diversification	Bathing diversification	Washing diversification	Cleaning diversification
44 (36%)	37 (31%)	52 (43%)	47 (39%)	47 (39%)

Notes: Percentages in parenthesis have a common denominator of N = 121
Source: Field survey by the author

I analyse the patterns of relationships among the demographic, institutional, and ecosystem variables in the following sections.

3.4 Data Analysis

Following Srinivasan and Nuthalapati (2019), I considered the determinants of water usage to be the social and economic features of the respondent households and other factors that may influence the access and utilization of panchayat ponds (Table 11). The number of household members, including children, pond-dependent households,[1] and the possession of livestock indicate the "load" factor on the pond in terms of the number of users. Various studies using the perspective of the commons highlight that community members without traditional user rights over the resources tend to be excluded from potential benefits. Therefore, the first principle in the Ostromian design framework is defining user and resource boundaries. I included factors such as house ownership and duration of residence in the current location to test the relationship. Access and utilization are influenced by the distance from the pond to the nearest motorable road. The surveyed ponds that existed in the middle of paddy fields, far away from the road, seemed to have non-optimal biophysical conditions and limited utilization.

Logistic regression models were fitted to estimate the impact of ecosystem variables and indicators of institutional strength and relative scarcity on utilization patterns of panchayat ponds in Palakkad. The motivation of this study was to identify the statistical patterns of the relationship between the rural community ponds and their users in India. When it comes to vital ecological assets like rural ponds, questions like who has access and for what purpose are hardly discussed in academic literature. The regression analysis was necessary to verify and quantify the utilization patterns of these ponds.

Understanding how access and utilization patterns differ along the axes of caste, class, and gender could be useful for scaling up resource governance models. The statistical significance of variables could have policy as well as future research relevance. In general, studies positioned in a political ecological framework have been criticized for offering critique than "generating or contributing to more concrete policy and governance solutions" (Bennett et al. 2018, 332). This study is an attempt to bring into conversation the theoretical strands of commons/CPR and political ecology to offer policy-relevant research.

3.4.1 Model

Following Gujarati and Porter (1999), I fitted binary logistic regression models to identify the predictors of utilization of panchayat ponds involving dummy dependent variables, with continuous categories. Specification of the bivariate logistic regression function for panchayat pond utilization is as follows:

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[1] The number of pond-dependent households is only an approximate figure based on household interviews.

$$\text{Logit}(P) = \log (P/1\text{-}P) \quad (1)$$

$$\text{Let } Pi = \Pr (Y = 1/X = xi) \quad (2)$$

$$\Pr (y = 1/x) = \exp^{x'b} / 1 + e^{x'b} = \log (Pi/1\text{-}Pi) = \text{Logit } (Pi) = \beta 0 + \beta 1xi \quad (3)$$

where Pi is the probability of utilizing the pond (dependent variable), xis are independent or predictor variables, β0 is the intercept, and β1 is the regression coefficient. The predictors included indicators of ecosystem health, institutional strength, and level of diversification of water sources.

In this model, the dependent-variable utilization of panchayat ponds is a binary categorical variable, and the independent/predictor variables include indicators of the ecological health of the ponds, institutional strength of the panchayats, and the extent of diversification of water sources. I ran separate regressions for each of the major usages of the panchayat pond.

In the regression models, I employed three variables as independent variables following Stoltzfus (2011). A rule of 10 states, "for every independent variable, there should be no fewer than 10 outcomes for each binary category (e.g., alive/deceased), with the least common outcome determining the maximum number of independent variables" (Stoltzfus 2011, 1101). Accordingly, for each binary category (in this case, usage/non-usage for a particular category), the smallest outcome is 31. This figure is taken from the primary data that indicated that 90 members used the pond for cleaning and 31 did not. For each, bathing and washing, 89 respondents used the community pond. Therefore, the logistic regression model could reasonably have three independent variables for a sample size of 121.

3.4.2 Hypotheses

As far as the overall position of the existing literature reviewed in the introduction is concerned, we might expect that the access and utilization of common water sources are mediated by social and economic variables, such as the caste, class, religion, and gender of the dependent population. The utilization could also be influenced by the relative scarcity and the availability of alternative water sources for various usages. The higher the level of diversification of water sources, the lower the utilization of ponds for various purposes. We can expect the level of dependency—in terms of the number of users—to impact the utilization frequency and ecosystem sustainability, given that the pond ecosystems under review are small in size, ranging from a few cents to less than two acres. The larger the dependency, the lower the ecological health parameters of the pond. Regarding the ecosystem health of the panchayat ponds, we can expect differences across the various locations of the district.

I tested the hypothesized predictor variables for statistical issues like multicollinearity. However, none of the model equations showed multicollinearity among the predictor variables when tested using the Variance Inflation Factor (VIF).

4. RESULTS

4.1 Access and Utilization Patterns

There was universal access to the panchayat pond in the surveyed panchayats, cutting across religion, caste, gender, and class, for the domestic purposes of drinking, cooking, bathing, washing, and cleaning.[2] However, there was a universal ban on utilizing the pond for commercial purposes.

The overall utilization patterns show that domestic purposes such as bathing, washing and cleaning are prioritized over irrigation and commercial purposes.[3] Out of the 121 respondents, 89 (73.6%) used the community pond for bathing and washing, while 90 (74.4%) members used it for cleaning purposes. Except in a couple of extreme cases, the dependent households did not utilize the ponds for drinking and cooking. The average number of households dependent on a pond is close to 60.

Studies such as Krishnan and George (2009) have found that non-recognition of ecological connections between land and water and "enclosures" of water within private land parcels has contributed to water scarcity in Palakkad and elsewhere in Kerala. The primary survey data too shows that more than 22% of the respondents have an insufficient amount of drinking water. In addition, 22% of the respondents receive drinking water only seasonally.

To overcome this scarcity caused by socioecological factors, the community depends on the panchayat ponds for their domestic needs. For drinking and cooking, own open well and panchayat pipe connections were the primary sources for respondent households. While 53% of households depended on their open wells, close to 45% relied on the panchayat pipe connection.

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[2] Utilization is recorded if any of the household members use the pond for a specific purpose. "Washing" primarily indicates washing of clothes, while "cleaning" indicates using the pond water for washing dishes, cleaning automobiles, etc.

[3] Frequencies are based on the recall for the previous week. Afterwards, I extrapolate these to the number of times in a year, factoring in the number of months of non-usage and non-availability of water in the pond, if applicable.

Almost three-fourths of the respondents utilized the panchayat pond—along with other sources such as wells and pipes—for bathing, washing, and cleaning. For irrigation, most of the cultivating households relied on canal irrigation.

4.2 Association between Pond Utilization and Demography: Correlations and Cross-tabulations

Significantly, ecological and institutional scores are positively and considerably correlated. In the case of the domestic purposes of bathing, washing, and cleaning, the composite ecological score is significantly and negatively correlated, though the coefficient is negligible (Table 4). This result could be interpreted thus: the higher the frequency of domestic usage, the lower the composite ecological score. On the other hand, the institutional score is directly and significantly associated with domestic usage frequencies but not with irrigation frequency.

The domestic usage frequencies and institutional strength are positively and considerably associated. Nonetheless, no such association exists between domestic or irrigation frequencies and CDS. Domestic utilization is not related to the distance of the pond to the road, the educational attainment of the respondents, or their household size. Another interesting association is between the number of household members and the extent of diversification of water sources. It shows that the number of members in the household and CDS are positively correlated. The household size is not associated with the frequency of utilization, indicating that the number of householders does not matter when utilizing the pond. At the same time, the number of dependent households is positively and significantly correlated to washing frequencies.

The findings do not provide evidence that religion and caste matter in bathing, washing, cleaning, and irrigation purposes (Table 5). Gender matters only in the case of usage for washing. Economic class, indicated by the main occupation, is pertinent in all domestic and irrigation purposes. Accordingly, the hypothesis that there is no relationship between class status and pond utilization stands rejected. Apart from class, respondent perceptions of the cleanliness of the panchayat ponds show a significant relationship with domestic purposes, while this is immaterial with respect to irrigation usage. Class alone matters in the case of pond utilization for irrigation.

Table 4: Correlation Matrix

S. No	Variables	1	2	3	4	5	6	7	8	9	10	11	12
1	Bathing utility frequency	—	.963**	.946**	0.076	.217*	0.051	-0.024	0.122	-0.171	.231*	-.279**	-0.098
2	Washing utility frequency	.963**	—	.980**	0.051	.265**	0.007	-0.042	0.141	-.206*	.209*	-.270**	-0.125
3	Cleaning utility frequency	.946**	.980**	—	0.046	.223*	0.014	-0.032	0.119	-.194*	.220*	-.293**	-0.162
4	Irrigation utility frequency	0.076	0.051	0.046	—	-0.171	.296**	.236**	0.033	0.049	0.151	-0.079	0.003
5	Pond-dependent households	.217*	.265**	.223*	-0.171	—	-.501**	-0.062	NA	NA	0.064	-0.008	0.072
6	Distance from the nearest motorable road in metres	0.051	0.007	0.014	.296**	-.501**	—	NA	NA	NA	NA	NA	-0.159
7	Educational attainment	-0.024	-0.042	-0.032	.236**	-0.062	NA	—	-0.039	NA	NA	NA	0.084
8	Total number of members in the household	0.122	0.141	0.119	0.033	NA	NA	-0.039	—	NA	NA	NA	.257**
9	Number of years spent in the current location	-0.171	-.206*	-.194*	0.049	NA	NA	NA	NA	—	-0.072	0.143	-0.124
10	Composite Institutional Score (CIS)	.213*	.209*	.220*	0.151	0.064	NA	NA	NA	-0.072	—	.268**	-0.016
11	Composite Ecological Score (CES)	-.279**	-.270**	-.293**	-0.079	-0.008	NA	NA	NA	0.143	.268**	—	0.044
12	Composite Diversification Score (CDS)	-0.098	-0.125	-0.162	0.003	0.072	-0.159	0.084	.257**	-0.124	-0.016	0.044	—

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
NA: Not Applicable
Spearman's rho used for correlation
Source: Primary survey data analysis

Table 5: Users of Panchayat Ponds and their Social and Economic Background: Chi-square Cross-tabulations

Social and economic background of the respondent	**Utilizers of the pond**	**Bathing**	**Washing**	**Cleaning**	**Irrigation**
Religion of the respondent	Hindu	73 (82)	73 (82)	74 (82)	10 (100)
	Non-Hindu	16 (18)	16 (18)	16 (18)	0
Caste of the respondent	OBC	47 (53)	47 (53)	49 (54)	4 (40)
	Non-OBC	42 (47)	42 (47)	41 (46)	6 (60)
Gender of the respondent	Female	51 (57)	52 (58)*	51 (57)	4 (40)
	Male	38 (43)	37 (42)*	39 (43)	6 (60)
Major source of income of the respondent	Daily Wage Labour	49 (55)*	50 (56)*	51 (57)**	0*
	Others	40 (45)*	39 (44)*	39 (43)**	10 (100)*
Economic category of the respondent	Priority	57 (64)**	58 (65)**	59 (66)**	5 (50)
	Non-Priority	32 (36)**	31 (35)**	31 (34)**	5 (50)
Perception of cleanliness of panchayat pond	Clean	79 (89)**	80 (90)**	79 (88)**	8 (80)
	Unclean	10 (11)**	9 (10)**	11 (12)**	2 (20)
Possessing farmland	Yes	29 (33)	28 (31)	28 (31)*	10 (100)*
	No	60 (67)	61 (69)	62 (69)*	0
Possessing livestock	Yes	19 (21)	20 (22)	22 (24)	5 (50)
	No	70 (79)	69 (78)	68 (76)	5 (50)

Notes: Percentage in parenthesis
*indicates significance level at $p < 0.05$
**indicates significance level at $p < 0.01$

Source: Primary survey data analysis

Most importantly, respondents' perception of the cleanliness of the panchayat pond is directly and moderately correlated with each of the domestic usage frequencies (Table 6). It is considerably and positively associated with the ecological health indicator, CES. Since the overall average score of institutional strength is high (the mean CIS is 92.73), the lack of association between the perception of cleanliness and institutional strength need not be a matter of concern, given that there is no expectation of a direct correlation. This is also true of the perception of cleanliness and the diversification score.

Table 5: Correlation of Cleanliness Perception with Utilization Frequency and Composite Scores

Spearman's rho	Perception of cleanliness of panchayat pond
Frequency of Bathing	.454**
Frequency of Washing	.481**
Frequency of Cleaning	.435**
Composite Institutional Score	0.139
Composite Ecological Score	.519**
Composite Diversification Score	0.078

Notes: ** Correlation is significant at the 0.01 level (2-tailed)
Source: Primary survey data analysis

4.3 Regression Results

4.3.1 Factors determining the utilization of the pond for bathing

I present the logit estimations for composite scores on institutional strength, the ecological integrity of the pond, and the extent of diversification of water in Tables 7, 8 and 9. I describe the marginal effects of each estimation, standard errors, and p-values in the tables.

Variables on the ecological score and diversification are statistically significant as factors influencing the usage of the ponds for bathing (Table 7). The positive sign of the ecological score indicates that for every one unit increase in the ecological score, the probability of an improvement in bathing usage increases by 0.0088%. Interestingly, the model shows that even as the diversification of water sources improves, there is a slight increase in the likelihood of usage of ponds for bathing. This result further highlights the importance of ponds in the lives of rural households in the study area.

Table 6: Determinants of Pond Utilization for Bathing

Independent variables	dy/dx	Std. Err	P>|z|
Composite institutional score	0.0028	0.0027	0.299
Composite ecological score	0.00889***	0.0024	0.000
Composite diversification score	0.0024**	0.0011	0.035

Notes: N = 121; LR chi2(3) = 25.38; Prob > chi2 = 0.0000; Pseudo R2 = 0.1815
Log likelihood = -57.210004
***, ** and * are significant at 1%, 5% and 10% respectively
Source: Primary survey data analysis

4.3.2 Factors determining the utilization of the pond for washing

Once again, the ecological score turned positively significant with respect to the use of the pond for washing. As with the bathing usage, a unit increase in the ecological score leads to an increase in the probability of washing usage by 0.0091%.

Table 7: Determinants of Pond Utilization for Washing

Independent variables	dy/dx	Std. Err	P>|z|
Composite institutional score	0.0045448	0.0027819	0.102
Composite ecological score	0.0091526***	0.0023605	0.000
Composite diversification score	0.0016185	0.0010906	0.138

Notes: N = 121; LR chi2(3) = 26.26; Prob > chi2 = 0.0000; Pseudo R2 = 0.1878
Log likelihood = -56.768265
***, ** and * are significant at 1%, 5% and 10% respectively
Source: Primary survey data analysis

Table 8: Determinants of Pond Utilization for Cleaning

Independent Variables	dy/dx	Std. Err	P>|z|
Composite Institutional Score	0.0049421*	0.0027351	0.071
Composite Ecological Score	0.0083938***	0.0022616	0.000
Composite Diversification Score	0.0012287	0.0010629	0.247

Notes: N = 121; LR chi2(3) = 23.78; Prob > chi2 = 0.0000; Pseudo R2 = 0.1727
Log likelihood = -56.963276
***, ** and * are significant at 1%, 5% and 10% respectively
Source: Primary survey data analysis

4.3.3 Factors Determining the Utilization of the Pond for Cleaning

When it came to the usage of the pond for cleaning, the institutional strength variable turned out to be positively significant, along with the ecological score (Table 9). A unit improvement in the institutional score leads to an increase in the probability of cleaning usage by 0.0049%. In this model too, the ecological score became a central determinant of pond usage.

5. DISCUSSION

The purpose of this research was to trace the access and utilization patterns of rural ponds in Kerala, identify the governance arrangement over these ponds, and assess their ecological health. Considering the above evidence, I attempt to situate these small freshwater bodies in a commons perspective.

Providing an overview of water-related works, Swyngedouw (2009) concludes that water research either focused on the physical aspects or the managerial issues of the problem, rather than on the difficult question of the political-economic relations binding the physical and managerial factors in socially differentiated ways. I find that unequal access to or control over waters results from a combination of factors, such as the particular geographical situation, techno-managerial choices, political and legal arrangements over the resources, and water inequalities.

There is universal access in the study scenario for the domestic usages of bathing, washing, and cleaning. Users have the right to access ponds for non-subtractable usages like bathing and washing, but—in most cases—not for rivalrous usages like irrigation. The local communities have prioritized domestic purposes over irrigation and commercial interests. Although there is some leeway for minor irrigation, no usage is permitted for commercial objectives. The result disproves the earlier hypothesis that access is mediated by caste, class, religion, and gender variables in the current context of Kerala. However, utilization patterns show class and gender differentiation, given that daily-wage earners and women, in general, tend to be more dependent on rural ponds (see Table 5). Also, in locations like Kizhakkencherry Panchayat, Dalit artisan communities living in poramboke (or revenue "wastelands") soak their bamboo in the nearby public pond (called *Cheerakuzhi kulam*) before making various products. For the marginalized communities, the public ponds support livelihoods (a washer community called Vannan uses Perumkulam pond in Nallepully GP, for instance) and are often their sole source of fulfilling domestic needs such as washing and bathing. Ghate, Ghate, and Ostrom (2013), in their study of harvesting patterns and the impact of communication in indigenous societies in Vidarbha, India, found that communities still tend to be non-exploitative, non-commercial, and cooperative even under the onslaught of marketization. In this study, I confirm this finding in the context of rural ponds in Kerala and underline the importance of these small freshwater bodies to the marginalized and dispossessed sections of the population.

The local panchayats are the custodians of the rural public ponds in Kerala. As these are vital ecosystems with contested uses and users, a clear and effective institutional arrangement is imperative to avoid the tragedy of open access. As the earlier discussion shows, the CIS—which signifies the aspect of collective action—is on the higher side with an overall mean score of 93 (see Table 2). At the panchayat, uses of pond waters are prioritized, rules are enforced, issues are deliberated, funds for maintenance are allocated, and actions are monitored, effectively creating a "new commons". I use the term "new commons", as most of these rural public ponds were privately held irrigation ponds before the land reforms in Kerala (field survey, 28 December 2019). It is similar to Bakker's study of public water supply in England and Wales; she notes that social struggles in the form of a countermovement led to institutional changes and reregulation and created a "new commons" like municipal water cooperatives, replacing water privatization.

Even as communities resist enclosures through collective action and "polycentric governance" (Ostrom 1990), the ecological health of the ecosystem under consideration does not necessarily improve (Nagendra and Ostrom 2014). However, in the present case, the parameters of local self-governance of rural ponds moved in coordination with the ecological health indicators. The CIS and the CES showed a significant positive correlation (see Table 4). My field survey showed that the panchayats, leveraging the National Rural Employment Scheme (NREGS) funds and spending their own funds, ensure regular upkeep of these rural ponds. Respondents across locations mentioned the role of women employed under NREGS in removing sludge and weeds from the ponds and desilting them at regular intervals.

In order to situate the rural ponds in a commons framework, let us review the role of contextual variables in the Ostromian framework and compare it with this study. Ostrom found that several contextual variables impact the level of cooperation, such as the size of the group involved, group heterogeneity, the relative scarcity of the good, marginal contribution to the collective good, the ability to make rules, the role of leadership and free-riding chances (Ostrom 2000). Ostrom and Varughese found that heterogeneity was not a significant predictor of the degree of collective action, as strong institutions could overcome that challenge (Varughese and Ostrom 2001). My study confirms the finding that heterogeneity is insignificant if institutions are in place to ensure equity in access. Various groups that are heterogeneous in terms of religion, caste, gender, occupation, education, wealth, household size, and duration of residence use the panchayat ponds in Palakkad. The number of dependent households was an insignificant predictor in the regression models, indicating that more than the size of the group, it is the nature of usage that matters.

Modest levels of scarcity were a prerequisite for a community to self-organize (Varughese and Ostrom 2001). The low overall CDS mean (38 out of 100) in the present case could indicate the relative scarcity of water for various usages. In their study to understand the predictors of groundwater access in the Godavari Basin in South India, Srinivasan and Nuthalapati (2019) also found that farmers started to economize water use when faced with actual scarcity. Relative scarcity and associated dependency over water commons seem to have some importance in my study, as the CDS turned significant in the logistic regression model predicting the usage for bathing—but not for washing and cleaning (Table 7).

The marginal contribution to the collective good as a determinant of collective action requires some reconsideration in light of the evidence from my study. Ostrom's design principles assemble "lessons learnt" from successful and not-so-successful self-governance systems (Ostrom 2010). While the design principles mention the social and economic ability of local communities to self-organize, we could add to them another layer considering the political ability of the same communities to pull resources from larger systems to support the local institutions. Ostrom (2005) mentions a "need to assess the costs of operating a system on users". In the case of panchayat ponds in Kerala, while the benefits are appropriated by the local communities, the provisioning costs are provided by the panchayats, which re-routes funds from the state and central governments. The local communities do not pay to utilize the pond—at least not directly; indirectly, though, panchayats have local tax revenues. This arrangement might appear, prima facie, unfair or even unsustainable to the institutional theory based on the "congruence between costs and benefits" borne by local users, and yet, is valid and significant as an inequality-reduction exercise. As Swyngedouw (2009) argues, the provision of water to big cities implies mobilizing water over great distances from different regions. Even if hugely disproportionate, the external fund flow to the decentralized rural entities could be viewed as reparations for the virtual water flows to the cities.

While acknowledging that searching for panaceas in resource governance is problematic in itself, Ostrom (2007) outlines that "some form of government ownership, privatisation, decentralisation, land reform or community control of resources is an appropriate solution to a particular social-ecological problem". Though useful in arraying the best practices of natural resource governance by local communities, Ostrom's theoretical frameworks are generally ahistorical and apolitical and tend to assume that users would equitably and sustainably manage the very resources they intend to govern. Her ambitious attempts to categorize "configurations of causal conditions affecting incentives, behaviors, and outcomes" might not capture the role of land reforms, decentralization, and government ownership in setting up community-controlled institutions and maintaining ecosystems. In the case of panchayat ponds in Kerala, a combination of factors and institutions—like the land reforms of the 1960s and 70s, government ownership at the local panchayat level (through Kerala Panchayat Raj Act 1994), the decentralization of power after the campaign in late 1990s, the policy treating water as "commons" (through the Kerala State Water Policy 2008), and community control—all together brought equity and sustainability as outcomes.

As regards community control, various pond-dependent groups—such as women and Dalits—actively resisted and, many times, even reversed unsustainable and unjust interventions, such as commercial fish-rearing, waste-dumping, and diverting pond waters for the irrigation of commercial and water-guzzling crops like banana (see section 3.3). Even when the fishing lease is operational, it is seldom on a commercial scale. Nonetheless, when the leasing of ponds for pisciculture clashed with the domestic uses of bathing and washing, the users mounted resistance in the panchayat meetings; this led to the cancellation of such leases in several instances—as in Puthukulam in Vadakkencherry GP. In this case, the lease was owned by the then panchayat president himself. Other respondents mentioned that whenever fishing leasers tried to reduce water levels during harvesting—as in Ullanoor Kulam in Nagalasseri GP—local users had successfully resisted such attempts.

Similarly, there are directives in many GPs that prohibit the usage of the pond for irrigation, especially during lean seasons like summer—for example, in Perumkulam in Chalavara GP. In the case of Angadikulam in Ongallur GP, women users resisted attempts to extract water for road construction. Waste dumping in and around public ponds was countered in panchayats like Eruthempathy, Vadakkencherry, and Puthupariaram. In all these instances, the local panchayat meetings were used to register the protests and undertake negotiations. These were essentially a political mobilization at the grassroots—an institutionalized "countermovement" that has led to sustainable and just outcomes. As Boelens (2014) mentions, "water is the source of collaboration and conflict, a basic means of mobilising people and a driving force behind local common property institutions".

The political mobilization driving these countermovements is essentially a movement towards decommodification (Kentikelenis 2017). Smessaert, Missemer, and Levrel (2020), in their synthesis of the present state of knowledge on the process of commodification, note that there is scope to understand "specific counter-forces" that result in the process of decommodification. Igoe and Brockington (2007) contend that neoliberalization involves reorganizing nature through forms of commodification. They note that the state stepping back through deregulation is a pervasive process of neoliberalization. We see reregulation—as opposed to deregulation—by the state in the case of rural ponds in Kerala. The land reforms undertaken by the state governments in the 1960s and 1970s have led to the commonization (Nayak and Berkes 2011) of these surveyed ponds in several locations, such as Chittur, Pattambi, Kuzhalmannam, and Kollemkode, among others. They are called *michabhumikulam*—ponds that the state took over through land reforms. Before the reforms, they were privately held and mostly used for irrigation. Later on, the local governance systems of panchayats often prioritized domestic utilization over irrigation and commercial usages. Grafton (2000) argued in favour of the state involving itself in resource governance, backing those engaged in collective action (Ostrom 2009). This argument sums up the politics of rural ponds in Kerala.

There remain several limitations to this study. Many puzzles are unsolved—like why, in some cases, indicators of institutional strength did not translate to the ecological health of the ponds, or why households that have lived in a locality longer tend to use the ponds less frequently. Moreover, I sought to identify only the patterns of relationships between ponds and their proximate populations. Another qualitative study is needed to flesh out the nature of their dependency. A limitation of this study is that I only attempted to study the utilization patterns of the respondents living near the ponds, and not all possible dependents—some of whom might live far away from the pond. In the future, researchers could conduct studies in multiple districts using a comparative framework.

6. CONCLUSION

The primary objective of my study is to understand how the politics of water access and utilization patterns impact the social justice and ecological integrity of rural ponds. Small freshwater bodies like ponds are vital ecosystems in the ecological, economic, and sociopolitical landscape. With its associated properties of excludability and subtractability, rural ponds can be classified as commons.

Learning about various models of local-level, community-led water governance—like the case in Kerala—can help craft better institutions that can govern natural resources equitably and sustainably. When it comes to successful cases of community action at the local and regional level, the evidence marshalled tirelessly by Ostrom and others provides a counter for institutional sceptics bogged down by mounting evidence of the "tragedy of commons" all around the world. However, her attempts were aligned towards building a "universal model" by identifying a set of "contextual" variables favourable for collective action, not necessarily rooted in a historical and critical context. The institutional theory assumes that community control itself could translate into equity and sustainability outcomes. However, as this study of rural ponds in Kerala shows, the role of the state in negotiating outcomes that are just and sustainable is central, and institutionalizing the relationship between the state and communities is crucial to decommodify ecosystems. Through this paper, I argue that equitable and sustainable ecological governance entails broadening the institutional edifice built by Ostrom and others by incorporating the process of commodification and decommodification.

The multiplicity of uses and users makes water bodies a contested space. In this study, I reiterate that integrating commons theory with a political ecology framework could highlight the political nature of resource governance. The local self-governments in Kerala have succeeded in ensuring universal access to rural ponds and often facilitate fair utilization, protecting the interests of the marginalized sections of the dependent population. Landless, marginalized communities, daily wage earners, and women are major users of these rural ponds, and they often resist and reverse unsustainable and unjust interventions in the pond. Further research is imperative to understand the underlying processes of these countermovements.

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APPENDIX

Table 9: List of Panchayat Ponds Surveyed in Palakkad, Kerala

S. No.	Name of the gram panchayat	Name of the selected pond	S. No.	Name of the gram panchayat	Name of the selected pond
1	Chalavara	Perumkulam	16	Puthunagaram	Padikkalpadom kulam
2	Thirumitta kode	Panamkulam	17	Anangandi	Aathamkott kulam
3	Parathur	Nellikulam	18	Kizhakanchery	Cheerakuzhi kulam
4	Nagalasseri	Ullanoor	19	Alathur (Kavasseri)	Kavalappara kulam
5	Mathur	Chathan kulam	20	Pattambi (Ongallur)	Angadi kulam
6	Nallepully	Perumkulam	21	Marutharod	Panchirikkad kulam
7	Eruthempa thy	Thalippara kulam	22	Puthupariaram	Kulathinpalla kulam
8	Mannarkad (Karimba)	Panayampado m kulam	23	Karimpuzha	Kattapara kulam
9	Kanjirapuz ha	Kallemkulam	24	Sreekrishnapur am	Kunnamkot kulam
10	Pattithara	Venkara kulam	25	Mankara	Marampurambu kulam
11	Koppam	Veluthedath kulam	26	Vandazhy	Kunnamkotkula m
12	Vadakkenc hery	Puthukulam	27	Ayilur	Thamarakulam
13	Kannadi	Chedayan kulam	28	Alanallur	Pakkath kulam
14	Ambalapar a	Mulayam kulam	29	Kumaramputh ur	Kattukulam
15	Mundur	Arakulam	30	Pattancherry	Chathan kulam

Source: Field survey

Table 10: Description of Variables Used in the Study

S. No	Variable	Definition and Categorical Coding	Mean	Standard Deviation	Minimum	Maximum
1	Religion	Religion of the respondent; 1 if Hindu, else 0	0.84	0.365	0	1
2	Caste	Caste of the respondent; 1 if belonging to OBC, else 0	0.53	0.501	0	1
3	Gender	Gender of the respondent; 0 if male, else 1	0.48	0.502	0	1
4	Occupation	Main occupation of the respondent; 1 if daily wage earner, else 0	0.48	0.502	0	1
5	PDS	Economic category of the respondent; 1 if belonging to priority category, else 0	0.55	0.499	0	1
6	Home	1 if the respondent has own home, else 0	0.92	0.276	0	1
7	Agriculture land	1 if the respondent is landless, else 0	0.64	0.483	0	1
8	Livestock ownership	1 if the respondent owns livestock, else 0	0.25	0.434	0	1
9	Land size	Size of the agricultural land owned by the respondent in cents	51.79	178.929	0	1600

S. No	Variable	Definition and Categorical Coding	Mean	Standard Deviation	Minimum	Maximum
10	Crop number	Number of crops cultivated by the respondent in a year	0.51	0.787	0	4
11	Commercial crop number	Number of commercial crops cultivated by the respondent in a year	0.28	0.686	0	4
12	Education	Number of years of schooling of the respondent	7.64	4.088	0	17
13	Household size	Number of members in the respondent household	4.63	1.831	1	13
14	Children	Number of children in the respondent household	1.31	1.204	0	5
15	Number of Years of local residence	Number of years the respondent has been living in the household	36.73	22.251	0.5	86
16	Drinking water availability	Amount of drinking water available in a year; 1 if sufficient, else 0	0.78	0.418	0	1
17	Period of availability of drinking water	Period of drinking water available in a year; 1 if whole year, else 0	0.79	0.412	0	1

S. No	Variable	Definition and Categorical Coding	Mean	Standard Deviation	Minimum	Maximum
18	Perception of cleanliness	The respondent's perception of cleanliness of panchayat pond; 1 if perceived clean, else 0	0.74	0.438	0	1
19	Dependent households	Pond-dependent households	59.14	37.928	0	100
20	Distance from nearest road	Distance from the nearest motorable road to the pond (in metres)	157.66	182.585	1	500
21	CIS	Composite Institutional Score	92.73	13.102	30	100
22	CES	Composite Ecological Score	65.19	18.777	29	100
23	CDS	Composite Diversification Score	37.52	36.567	0	100

Source: Field survey and author's calculations