Waring, T. M. 2011. Ethnic forces in collective action: diversity, dominance, and irrigation in Tamil Nadu.
*Ecology and Society* **16**(4): 1.
http://dx.doi.org/10.5751/ES-04265-160401

*Research*

# Ethnic Forces in Collective Action: Diversity, Dominance, and Irrigation in Tamil Nadu

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ABSTRACT. Mounting evidence suggests that ethnic interactions damage cooperation in the provision of public goods, yet very few studies of collective action in common pool resource management have found strong evidence for the effects of ethnic diversity. Research on both public goods and common pool resource management that does find negative ethnic effects on cooperation tend to ignore the importance of interethnic relationships, particularly ethnic inequality, stratification, or dominance. This study presents data from agricultural villages in Tamil Nadu's Palani Hills to test the importance of a range of ethnic effects using caste interactions in a traditional irrigation system. I provide corroborating evidence of a negative cooperative effect of ethnic diversity, but also demonstrate that factors of ethnic dominance such as hierarchical stratification and demographic dominance strongly determine outcomes in collective irrigation management. I argue that the most important measure of equity, irrigation access, is socially, technologically, and institutionally embedded, and demonstrate that the distribution of irrigation channels is explained by measures of inequality, such as wealth inequality, Dalit status, and demographic dominance.

Key Words: *cooperation; irrigation; ethnic diversity; ethnic dominance; India*

## INTRODUCTION

> *One theme that emerges in reviewing the role of inequality is that the problems of successful commons management are not necessarily based on the characteristics of the natural resource itself – as the earlier, tragedy-of-the-commons tradition would have it – but rather the more prosaic problem of getting people to cooperate.* Bardhan and Dayton-Johnson 2000:17.

Theory suggesting that human populations inevitably deplete common resources (Olson 1965, Hardin 1968) has been invalidated with the repeated documentation of successfully managed common pool resources, and a voluminous literature on collective action in community resource management (Ostrom 1990, 2007, Ostrom et al. 1992). Despite the numerous factors that have been found to contribute to successful collective action in common pool resource management (Feeny et al. 1990), no mature theory of commons management exists (Agrawal 2002). The heavy focus on ecological and economic variables (e.g., see Varughese and Ostrom 2001) leaves a theory-gap in the common pool resource literature on the influences of cultural and ethnic forces.

Evolutionary anthropology provides a clear and applicable theory, which proposes that cultural or ethnic groups have evolved in part as a means to solve collective action problems (Richerson and Boyd 2005). This premise is supported by evidence on cooperation in psychology (Fiedler 1966), anthropology (Henrich et al. 2004), and economics (Gintis et al. 2003). This theory posits ethnic groups evolve as natural containers for human cooperation. Ethnic groups come into being via the coevolution of culturally transmitted ethnic markers and payoff-relevant, often cooperative, behavior (Efferson et al. 2008). Within a cultural or ethnic group, cooperation and behavior are maintained by the strength of reciprocity and punishment (Fehr et al. 1997, Gintis 2000, Fehr and Gachter 2002, Nowak and Sigmund 2005, Habyarimana et al. 2007). Accounting for cooperation within cultural groups helps to explain cooperative breakdown in multiethnic scenarios. Because cooperation is commonly highest within bounded groups (Bernhard et al. 2006), adding more ethnic groups decreases global cooperation, and gives rise to an 'ethnocentric equilibrium' in which altruism within groups coevolves with antagonism between groups (Choi and Bowles 2007). This evolutionary theory of ethnic cooperation should apply well to cases of community-based natural resource management and small-scale common pool resource systems so common in human evolution and so often studied in the collective action tradition.

The negative cooperative effect of ethnic diversity has been observed on the large scale. Regional studies show ethnic diversity damages the ability of societies to create and maintain public goods (Easterly et al. 1995, Alesina et al. 1999, Miguel and Gugerty 2005, Ruttan 2006, Baland et al. 2007). These regional studies beg the questions of what cultural and ethnic mechanisms govern cooperative patterns observed at the large scale and whether increasing numbers of ethnic groups decreases environmentally relevant cooperation on the individual level.

A second distinct ethnic force is that of ethnic dominance. Ethnic dominance occurs when ethnic groups differ not only by social identity, but also by a culturally reinforced social ranking in which one's ethnicity determines one's class (Horowitz 2000). Collier (2001) argues that much of the

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observed effect of ethnic diversity is better explained by the strength of dominance between ethnic groups. However, testing ethnic dominance has proven difficult. Because minimal ethnic diversity is a prerequisite for ethnic dominance, the cooperative effects of dominance and diversity occur simultaneously. Mathematical theory also implies that ethnic diversity and dominance may be very tightly linked. A model of the coevolution of social stratification with ethnic differentiation suggests that the two factors are mutually reinforcing in many cases (Henrich and Boyd 2008). If the Henrich and Boyd model is representative, ethnic diversity and ethnic dominance should often co-occur in regions with economic surplus. Borgerhoff-Mulder et al. (2009) find that the ability of agricultural populations to amass material wealth through economic surplus explains why economic inequality is greater for agrarian societies than for horticultural, foraging, and industrial societies. India is a region where both significant ethnic diversity and inequality are nearly ubiquitous under the surplus conditions of agricultural production.

Village irrigation systems in India have been extremely well studied, and scholars have found that intercaste relationships make a significant difference on outcomes. Wade's (1987) study of village irrigation systems in Andhra Pradesh found that greater caste homogeneity was conducive to cooperation in irrigation systems. Bardhan (2000) also found that caste homogeneity increased the likelihood of cooperative behavior in irrigation systems in Tamil Nadu. Both Bardhan and Wade used caste homogeneity of villages as the main theoretical variable, which is a related but limited metric of true ethnic diversity. Despite the overwhelming ethnographic and anecdotal evidence on the importance of caste-based hierarchy and dominance (e.g., Dumont 1970), published quantitative evidence on the effects of ethnic dominance on the individual level is nonexistent.

Despite ample evidence and theory that both ethnic diversity and ethnic dominance may play critical roles in general cooperation and collective action in natural resource management, one or both of these ethnic forces are often ignored. The focus of this paper is to examine the effects of ethnic diversity, ethnic dominance, and their articulation on cooperation in and perceptions of a traditional irrigation system in South India. I will test the two main hypotheses: (1) increasing ethnic diversity reduces community cooperation and perceptions of collective action efforts (e.g., Easterly et al. 1995, Miguel and Gugerty 2005); (2) ethnic dominance additionally reduces cooperation and collective action perceptions (Collier 2001).

## BACKGROUND

The upper Palani Hills are home to 20 agricultural villages ranging in size from ~500 to ~6000 people and varying from 3 to 13 caste groups per village. Table 1 summarizes the traditional village positions by caste membership across the six study villages, and outlines the significance of caste-based ethnic social stratification in village life. The outright oppression of 'servant castes' or Dalits, also called Harijans, untouchables, or Scheduled Castes/Tribes, is common in Tamil Nadu (Mangubhai and Irudayam 2000) and India at large. However, the traditional village-level institutions that still use caste to determine social roles are increasingly rare.

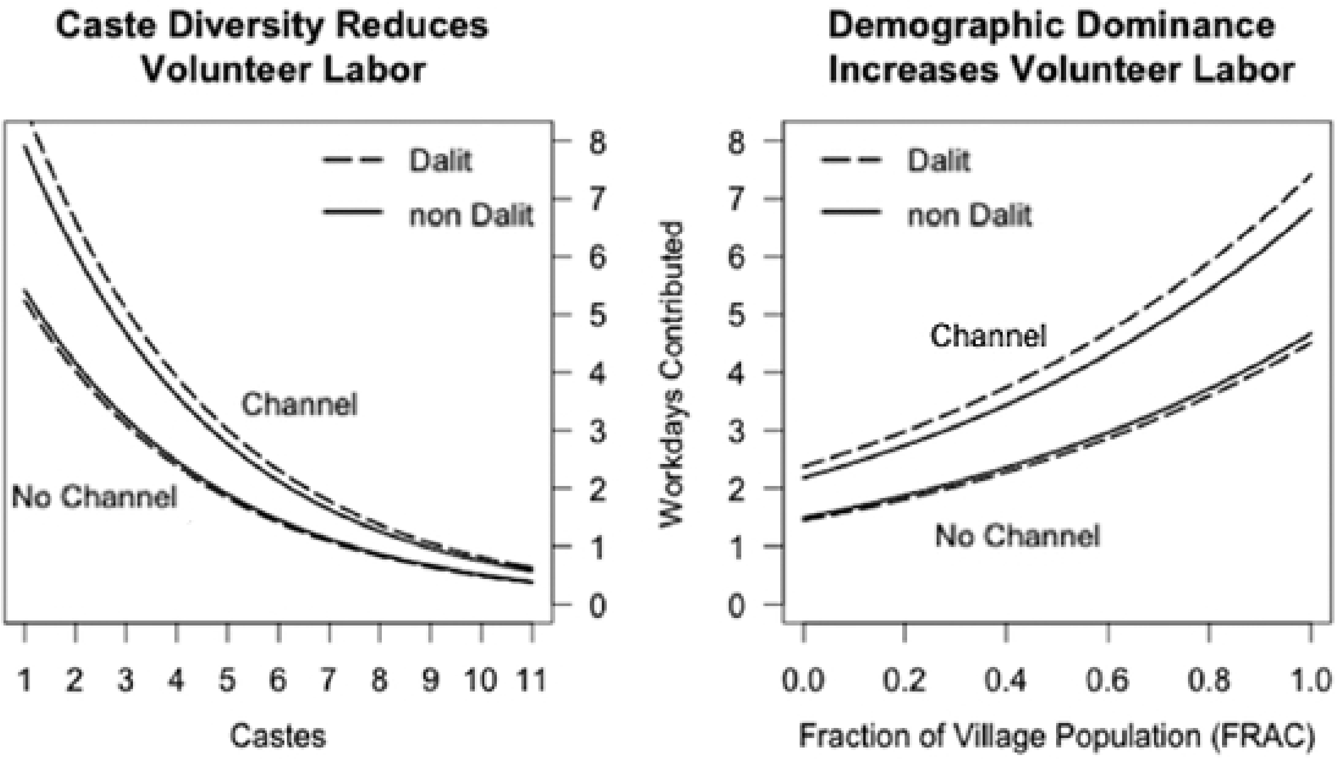
The traditional village irrigation system is a highly cooperative enterprise, and it bears significant resemblance to other irrigation systems in the Ramnad and Sivaganga regions of Tamil Nadu (Mosse 2006). In the Palani Hills, this irrigation system is a formal part of the village council. Village leaders convene village-wide meetings several times a year to conduct village business. These meetings largely focus on festival preparation, and communal works projects including the organization village workdays for maintaining the irrigation channels and ponds.

**Table 1.** Caste-wise distribution of traditional village leadership and servant positions in six study villages. The Sakkliyar are the predominant servant caste in the Palani hills region. See appendix for further detail on traditional village structure and ethnographic background. The term Dalit refers to the servant groups also termed Harijan, untouchable, or Scheduled Caste/Tribe.

| Caste group | Leadership positions (inherited) | Servant positions (appointed by leaders) | Regional Status |
|---|---|---|---|
| Manadiyar | 10 | - | Village Leader |
| Asariyar | 8 | - | Village Leader |
| Mudaliyar | 3 | - | Middle |
| Pillaiyar | 3 | - | Middle |
| Chettiyar | 2 | - | Middle |
| Reddiyar | 2 | - | Middle |
| Thevar | 1 | - | Middle |
| Sakkliyar | - | 98 | Dalit |

Preliminary ethnographic research provides a sketch of these irrigation systems. Village leaders appoint a number of official irrigators, called "neer-nikam," who oversee the distribution of irrigation water during the dry season from January to May. A neer-nikam is responsible for maintaining the irrigation channels, overseeing water distribution, and quelling conflict between farmers. A neer-nikam distributes water when the village storage pond is full, and serves each farmer across the channel network in turn. In some villages, farmers pay the neer-nikam a small per-acre price for water. The frequency of irrigation for a farmer depends on the amount of water available in the village pond. We are interested in the variation in actual irrigation behavior and perceptions of the successes and failures of the irrigation system.

**Fig. 1.** Influences on volunteer irrigation labor (workdays). LEFT: Negative binomial model predictions of the effect of CASTES show that increasing caste diversity decreases estimated cooperative labor dramatically, whether individuals have CHANNEL access or are Dalit. RIGHT: Estimates of the effects of demographic dominance (FRAC) on workdays shows that increasing ego-centric caste homogenetiy increases willingness to contribute to the upkeep of the irrigation system. The term Dalit refers to the servant groups also termed Harijan, untouchable, or Scheduled Caste/Tribe.




## METHODS

We conducted a semistructured, caste-stratified survey of farming households from six villages in the Palani Hills region of Tamil Nadu between April and June 2008. I selected six villages with functioning traditional communal irrigation systems, which varied in size, number of castes, and distance from the local city, Kodaikanal (Appendix 1 Figure 1). In each village all castes with 10 or more households were subsampled, and a minimum of nine households were surveyed for each caste group. Villages contained neighborhoods segregated by caste, affording efficient randomized sampling. I calculated the sample size for each caste, and sampled at random within each ethnic neighborhood. The final sample included 258 households across the six villages. Seven iterations of the survey were field tested in part or in full. Every question was printed in English and Tamil, and Tamil text was frequently back translated to ensure accuracy. Surveys were administered verbally by six research assistants in Tamil and recorded in English. Ambiguities in translation were addressed the same day the survey was recorded before leaving the village.

Cooperation was measured as workdays, the sum of days of participation in five specific types of irrigation work the respondent reportedly participated in during the last year. Attendance at these workdays is voluntary and enforcement is mostly verbal. Free riders still gain the benefits of a functioning irrigation system. In a social setting with strong ethnic dominance such as the master-servant relationships in the study region, cooperation might be the result of coercion. It is therefore necessary to include other measures of the success or failure of the cooperative system. Private individual perceptions provide a measure of the social interactions underlying choices to cooperate. I included two composite variables measuring respondents' perceptions of the adequacy and fairness of the irrigation system. Adequacy and fairness are both aggregate measures from five individual survey questions and display high item reliability (Cronbach's a > 0.67). Response variables are detailed in Table 2.

Predictor variables detailed in Table 3 are broken into individual and village level variables. Individual variables include standard demographic information, e.g., age, size of

**Table 2.** Response variable descriptions. See appendix for response variable correlations calculated using restricted maximum likelihood. Note: a NeerNikam is responsible for maintaining the irrigation channels, overseeing water distribution, and quelling conflict between farmers.

| Variable | Type | Description |
|---|---|---|
| workdays | days / yr<br>poisson | Number of village-wide communal workdays attended in the last year for work on ponds, channels, paths, and emergency repairs. (Mean = 3.1). Only eight farmers reported above 10 workdays, and two outliers (reporting 49 and 64 days worked) were additionally given low overall reliability rankings by research assistants, and excluded from the analysis. |
| adequacy | 0 - 5<br>index<br>binomial | Sum of four binary response variables on the relative adequacy of the irrigation system. Questions 36, 37, 38, 39, 43 from survey appendix, paraphrased:<br>Is there enough water for all?<br>Is there enough water for you?<br>Same or better water availability than other villages?<br>Same or better water availability than 10yr ago?<br>Is water distribution reliable here?<br>Questions 38 and 39 were recoded as binary variables.<br>Item reliability: Cronbach's a = 0.699 |
| fairness | 0 - 5<br>index<br>binomial | Sum of five binary response variables about procedural fairness in the irrigation system. Questions 56, 57, 58, 59, 60, paraphrased:<br>Does NeerNikam distribute water fairly?<br>Do village leaders keep NeerNikam honest?<br>Are you satisfied with irrigation system fairness?<br>How fair are irrigation rules?<br>How fair are penalties for breaking irrigation rules?<br>Questions 59 and 60 recoded such that completely = 1 and mostly = 1, not = 0, and no rules = NA.<br>Item reliability: Cronbach's a = 0.670 |

household, years of education, household wealth, irrigation channel access, as well as caste-relevant information such as the proportion of the village population represented by the respondents' caste (FRAC) and Dalit status (DALIT). FRAC is a homogeneity measure similar to the village-level homogeneity measures used by Wade (1987) and Bardhan (2000) except that FRAC is a respondent-centric measure of village homogeneity, complementary to the number of castes. The DALIT variable is a binary individual measure of the Dalit status of the respondent and a concise measure of ethnic dominance. Village-level variables include a simple measure of caste diversity, i.e., the number of castes, and controls for village population, distance from the regional city, and the Gini coefficient of village wealth inequality. Economic inequality has been well studied as a driver of cooperation. For instance, Bardhan and Dayton-Johnson (2007) found that an increase in landholding inequality (measured by the Gini Coefficient) in irrigation systems of Tamil Nadu increased water-related conflict, and the same authors also discovered that economic inequality weakened social sanctioning and the enforcement of collective agreements (Bardhan and Dayton-Johnson 2002). I included the WEALTHGINI variable to control for such wealth effects.

Population size and diversity are always correlated in any human settlement because the number of individuals must increase with the number of groups. This is also an inescapable feature of population structure in the study region. Larger villages are not necessarily more diverse, but more diverse villages are always larger. Because I sampled villages across the diversity gradient, I was forced to sample across the population gradient as well. The study design attempted to account for this by using a quasi-factorial natural experiment on the three variables of population size, distance from city, and caste numbers. I intentionally added a larger, less diverse village, Mannavanur, and a small, more diverse village, Vilpatti, to the sample to better distinguish the effects of population and caste diversity. These efforts improve the accuracy and reliability of estimates.

Naturally, pairwise correlations showed a strong association between population and numbers of castes (0.89). Such colinearity within the predictors would be a problem if both population and caste diversity were variables of theoretical interest. However, population is included only as a necessary and important control variable. Nonetheless, I calculated variance inflation factors (VIFs) as a measure of multicolinearity for each regression, and report the maximum VIF for each regression in Table 4. Caste diversity was the variable with the largest VIF in all regressions, yet it never broached the heuristic level of 10 suggested by Fox and Monette (1992) as a sign of significant colinearity. In addition,

**Table 3.** Description of individual and village-level predictor and control variables. Variables of theoretical interest include DALIT, FRAC, and CASTES. Other variables are included for statistical control.

Individual Level Variables

| Variable | Type / unit | Description |
|---|---|---|
| AGE | yrs | Age of respondent in years. |
| HHSIZE | # | Household size, in individuals. |
| EDUC | yrs | Education level of respondent. |
| LNWEALTH | 1000 Rs. | Log total value of owned items, in 1000 Rs. Increments. Wealth = 0.01 + livestock*10 + pumps*5 + house*300 + two-wheeled-vehicle*50 + four-wheeled-vehicle*750 + acres-owned*7000. |
| FRAC | 0 - 1 | Proportion of village population represented by own caste. |
| DALIT | binary | Dalit status (1), all others (0). |
| CHANNEL | binary | Irrigation dependency. Question 33: Is the land you work on connected to the channel? 69% responded ‘yes’. |

Village Level Variables

| Variable | Type / unit | Description |
|---|---|---|
| LNPOP | # | Log village population as reported by the 2001, Indian Census or estimated by the Panchayat clerk for that village, 2008. |
| DISTANCE | km | Distance from Kodiakanal. Kodaikanal (population 32,931) is the closest city and provides influential social and economic opportunities and cultural contacts (Registrar General & Census Commissioner, India 2001). |
| CASTES | # | The number of Jathis in a village with a population of more than 10 households. |
| WEALTHGINI | 0 - 1 | The Gini coefficient of estimated wealth, as estimated above, by village per Milanovic (1997). |

I computed population-adjusted caste diversity correlations for each response variable to test for residual predictive power once the effect of LNPOP had been removed from both CASTES and response variables. The results are collected in Table 4. Because there is a natural colinearity between number of individuals and the number of groups, I must model both population and numbers of castes to recover useful estimates of the effects caste diversity.

I used hierarchical multiple regressions to incorporate both individual and village-level predictor variables, and a random effect for village to account for any unmeasured village-level effects. I fit binomial regressions for indices and poisson-family (negative binomial) regressions for count data (workdays). If village-level variance was close to zero (< 0.005) in the full random-effects models, fixed effects models were reported. I discuss only correlations with at least 95% confidence. Analyses were computed in R 2.9.2.

## RESULTS

Multiple regressions revealed a negative cooperative effect of ethnic diversity (Hypothesis 1). Greater numbers of castes in a community were associated with less frequent contributions of voluntary labor to the cooperative irrigation system. This evidence supports the hypothesis that ethnic diversity reduces cooperation, and matches findings from the literature. Interestingly, I found no evidence that perceptions of the irrigation system are themselves negatively influenced by caste diversity; instead ratings of the adequacy of the irrigation system increased with caste diversity, taking all other variables into account.

Regression results also yielded evidence of a negative cooperative effect of ethnic dominance (Hypothesis 2). Individuals in larger caste groups were more likely to cooperate, to perceive the system as fair. Dalit individuals were less likely to rate the system as fair. Table 5 summarizes the support for hypotheses 1 and 2, and Table 4 presents fitted model estimates.

Cooperation in the irrigation system, measured as workdays contributed, was strongly influenced by caste diversity, village population, caste demographic asymmetries, and irrigation access. Workdays declined with increasing caste numbers, matching both predictions and prior findings. The model estimates that the addition of a new caste with 10 households or greater would reduce the average workdays contributed by 25%. Workdays also increased with growing caste homogeneity, FRAC, within a village, such that increasing the size of one’s own caste from zero to 50% of the village population was linked with a 77% increase in the number of days worked. Holding other factors constant, increasing a village population by 1000 households, a change equivalent to the difference between the smallest and largest villages in

**Table 4.** Regression results and diagnostics. Coefficients with standard errors in parantheses. Bold estimates have 95% confidence or greater. Max variance inflation factors (VIF) is the largest variance inflation factor for any predictor in the given model. A VIF of 10 or greater is considered an indication of multicolinearity (Fox and Monette 1992). †A random-effects poisson was over-dispersed (dev/df = 2.17; Lindsey 1999), while a negative binomial model without village was not (dev/df = 1.29). Village-level variance were calculated with a mixed effects poisson. ‡The diversity predictor variable used for workdays was number of castes with 10 or more households.

| | Workdays | Adequacy | Fairness |
|---|---|---|---|
| Family | negative binomial† | binomial | binomial |
| Intercept | -1.58 (0.83) | **-3.43 (1.03)** | -2.45 (1.31) |
| **Village-level** | | | |
| LNPOP | **0.77 (0.15)** | -0.25 (0.13) | **0.57 (0.19)** |
| DISTANCE | **-0.01 (0.01)** | 0.00 (0.01) | **0.02 (0.01)** |
| CASTES‡ | **-0.26 (0.08)** | **0.16 (0.06)** | -0.11 (0.09) |
| WEALTHGINI | **-0.03 (0.01)** | **0.05 (0.02)** | **-0.11 (0.02)** |
| **Household-level** | | | |
| AGE | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.01) |
| EDUC | -0.01 (0.02) | -0.01 (0.02) | -0.02 (0.02) |
| HHSIZE | 0.06 (0.04) | 0.06 (0.05) | **0.15 (0.06)** |
| LNWEALTH | -0.01 (0.04) | -0.01 (0.04) | **0.22 (0.06)** |
| FRAC | **1.14 (0.44)** | 0.27 (0.44) | **2.56 (0.64)** |
| DALIT | -0.03 (0.23) | -0.15 (0.25) | **-1.24 (0.58)** |
| CHANNEL | **0.38 (0.17)** | **0.96 (0.18)** | **3.36 (0.28)** |
| DALIT*CHANNEL | 0.12 (0.31) | 0.36 (0.33) | **1.95 (0.67)** |
| **Village variance** | | | |
| Full Model | 0 | 0.001 | 0 |
| | | | |
| **Model Fit & Diagnostics** | | | |
| ML pseudo-$R^2$ | 0.22 | 0.28 | 0.94 |
| DF | 241 | 243 | 243 |
| Deviance | 310 | 143 | 473 |
| Max VIF | 7.9 | 7.2 | 7.2 |

the sample, would increase the number of workdays an individual attends by a factor of 1.7 (a 70% growth). A farmer with a channel, all else being equal, would contribute 150% the number of workdays that a farmer without a channel would contribute, on average. DISTANCE was negatively correlated with workdays in the model such that a 20 km additional distance to the regional population center also equated to a 25% reduction in workdays contributed. Other effects were either not significant at the 95% level, or were of very small effect size. WEALTHGINI was negatively associated with workdays, but the effect was exceedingly weak (a change of 0.27 WEALTHGINI only equates to a 1% decrease in workdays contributed). Figure 1 presents model estimates for the influence of caste diversity (CASTES) and ethnocentric homogeneity (FRAC) on volunteer workdays.

### Perceptions of adequacy and fairness

Perceptions of adequacy and fairness showed very distinct patterns of correlation. Adequacy perceptions responded with significant and large effects to CASTES and CHANNEL, whereas fairness perceptions were not correlated with CASTES, but with many other variables, including DALIT.

The irrigation adequacy index is the sum of five yes/no responses, and ranges from zero to five (mean = 1.9, SD = 1.5). Sixty-six percent of farmers scored two or less. CASTES, LNWEALTH, and CHANNEL were all positively associated with the adequacy. In the model, having a CHANNEL connection made farmers 2.6 times more likely to answer ‘yes’ to an additional question in the adequacy battery than if they did not. Adding additional caste equated to a 17% increase in the odds of increasing a farmer’s rated adequacy score. An increase in wealth inequality equivalent to the largest change in the sample villages[1] increased the odds of another adequacy mark by only 1%.

Fairness was the sum of five binary response variables on the institutional equity of the irrigation system. Responses were bimodal, with 34% producing a score of zero, and 51% rating the system with a score of four or five. Perceptions of fairness were inflated by having irrigation access, being a member of a demographically dominant caste, but were damaged by DALIT status. The odds of farmers with a CHANNEL responding with an additional ‘yes’ to the questions on procedural fairness was nearly 30 times the odds of those

**Table 5.** Multiple regressions provide support for both hypotheses. Hypothesis 1 - Increasing ethnic diversity reduces community cooperation and perceptions of collective action efforts. Hypothesis 2 - Ethnic dominance additionally reduces cooperation and collective action perceptions. The effects of the FRAC variable support of both dominance and diversity hypotheses because membership in a larger ethnic group simultaneously decreases ethnic diversity and increases ethnic power differentials, the fundamental aspect of ethnic dominance.

| | | Perceptions of cooperation | |
|---|---|---|---|
| Support for Hypothesis | Workdays | Adequacy | Fairness |
| **H1:** diversity damages cooperation, perceptions of cooperation | **Yes**<br>Workdays decline with diversity, increase with FRAC | **No**<br>Adequacy increases with diversity | **Yes**<br>Fairness increases with FRAC |
| **H2:** dominance damages cooperation, perceptions of cooperation | **Yes**<br>Workdays increase with FRAC | - | **Yes**<br>Fairness increases with FRAC decreases with DALIT |

without. Holding other factors constant, Dalits responded 'yes' with only 0.3 times the rate non-Dalit did. Given the main effects of DALIT and CHANNEL, the odds of a Dalit with a channel indicating another unit of fairness was seven times that of a Dalit without a channel. Given the model fit, an additional million rupees of wealth correlated with a fivefold increase in the likelihood to rate the irrigation system as fair. An additional two persons in a household was associated with a 36% increase in the odds of a fair rating. Finally, a change in FRAC (demographic dominance) of 0.5 corresponded to a fourfold increase in the odds of a fair rating. Weaker effects included LNPOP, ALLCASTES, WEALTHGINI, and DISTANCE. Holding other effects constant, the model estimated that the odds of an additional unit score are 49% greater for a population with an additional 1000 households, and 46% greater for a village an additional 20 km from Kodaikanal, although 11% less for villages with an extra caste, and 3% less for an increase wealth inequality equivalent to the change from Palangi to Keelanavayal. Figure 2 presents the estimated effects of FRAC and CHANNEL on perceived fairness.

## Control variables

Of the village level control variables, population and distance were both important. Increasing population was associated with more volunteered labor, and a higher fairness rating. This positive effect of population size contradicts the standard game theoretic framing of cooperative dilemmas in which cooperation is expected to become more difficult to achieve as group size increases. These results suggest instead that cooperation (workdays contributed) and perceived fairness increase with population. This finding aligns with a strong cross-cultural pattern of greater cooperative punishment in larger populations (Henrich et al. 2010). Distance from Kodaikanal was associated with less volunteer work on irrigation projects and a greater fairness rating. The effect of distance may be due to the effect of cultural exposure, not included in the models. The WEALTHGINI measure of inequality, often strongly correlated with response variables, consistently had a very small effect size (< 5% change).

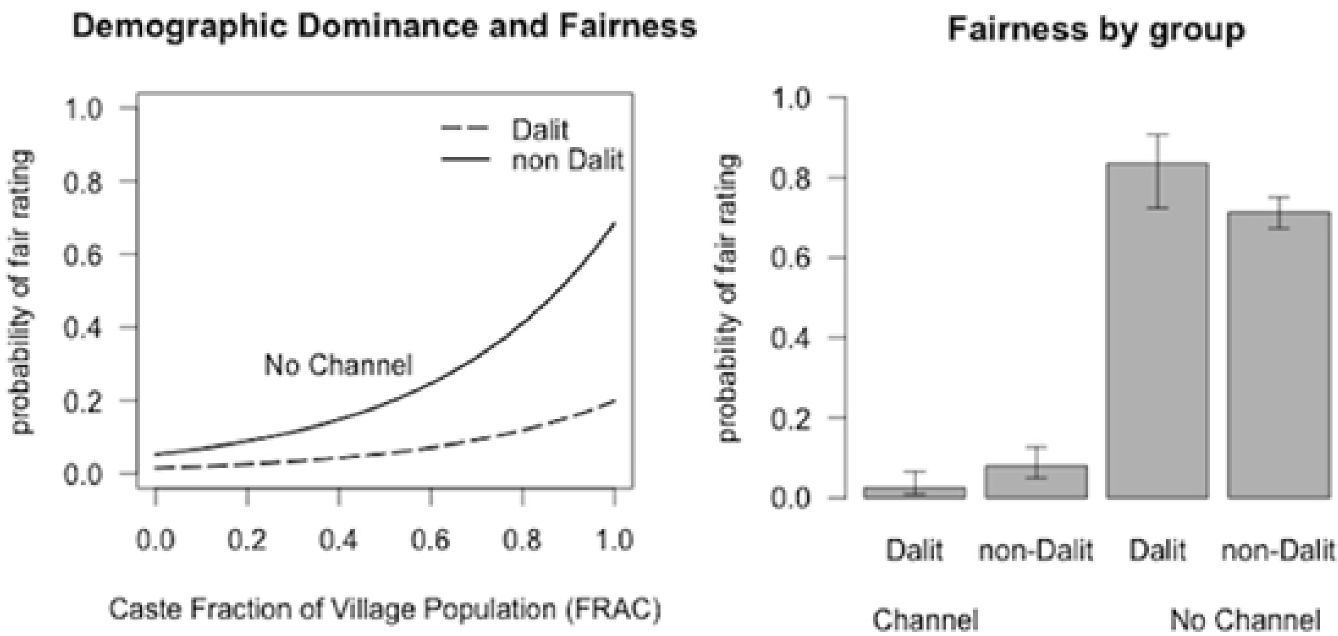
Individual-level control variables, i.e., age, years of education, and household size, were rarely important predictors, having very small effects on response variables. Wealth was an important predictor of perceived irrigation fairness. Farmers with greater wealth were more likely to report the irrigation system as fair, indicating a potential for bribery. The exception to this pattern is the CHANNEL variable. Access to irrigation channels is a defining measure of involvement in an irrigation system, and was a central explanatory factor across all response variables. Having an irrigation channel would improve evaluation of and participation in the irrigation system. Farmers with channels contribute more labor to irrigation projects and rate the irrigation system as more adequate and fair.

## Embedded ethnic inequalities

The hidden importance of the CHANNEL variable is in its relationship to caste boundaries. Channels are distributed very unevenly between caste groups. Although over 75% of non-Dalits in our sample have channel access, less than 40% of Dalits have the same privilege. This disparity raises possibility that the technical factors of irrigation access may have been generated by social and ethnic forces, perhaps including caste diversity and dominance. Additionally, because the institutions and traditions of village management and irrigation are shared across Tamil Nadu, and the channel network was created within a hierarchically organized caste-based social structure, the distribution of channels is itself likely determined by village social factors.

To test whether CHANNEL might also be in part determined by social factors, I used an Akaikie multimodel comparison exercise to examine the best predictors of channel ownership. Akaike's Information Criterion (AIC) computes the relative fit of a suite of candidate models in explaining the same data, here channel distribution. The procedure ranks each model

**Fig. 2.** Influences on perceived fairness. LEFT: the estimated probability of a fair rating given different relative sizes of the respondent's caste within a village (FRAC). Probability estimates show that non-Dalit fairness perceptions climb faster than Dalit perceptions with increasing demographic strength. Estimates are for individuals with no channel access, because those with access reliably rated the irrigation system as very fair. RIGHT: the effects of Dalit status and channel access on perceptions of fairness in irrigation, 95% confidence intervals. The term Dalit refers to the servant groups also termed Harijan, untouchable, or Scheduled Caste/Tribe.




with an Akaike weight, the sum of which equals one. The model with the largest Akaike weight has the least mean squared error in the candidate set of models. The AICc variant additionally penalizes models for additional parameters, which reduces overfitting (Burnham and Anderson 2002). Five candidate logistic regression models used different variable combinations. 'Base' included no predictors, 'village' included only village level predictors, 'individual,' only individual level variables, 'all,' all variables, and 'inequality,' only included FRAC, DALIT, LNWEALTH, and WEALTHGINI. Models were ranked for predictive accuracy using the df-penalized AICc (Table 6).

Inequality was best-fit model with an Akaike weight of 0.97. The second best-fit model was individual with an Akaike weight of 0.01. This model comparison demonstrates that access to irrigation channels is uneven, and that wealth, demographic dominance, and Dalit status may drive channel access. Table 7 summarizes the effects of inequality variables on the chances of having channel access. The effect of wealth inequality is small, with a change in WEALTHGINI equivalent to moving from Keelanavayal to Palangi corresponding to a 2% reduction in chances of having a channel. Wealth has a large effect, having a 100,000 more rupees makes a farmer 3.4 times more likely to have a channel. Increasing the demographic dominance of one's caste to 50% of village population is associated with twice the odds of having a channel. Finally, being a DALIT reduces one's chances of having a channel by 77%, all else being equal. It is worth noting that the AIC procedure did not weight models including CASTES highly, suggesting that caste diversity does not play the decisive role that Dalit status, wealth, and ethnic demographic inequalities do.

That factors of inequality best explain the distribution of channels among people in these six villages inflects the interpretation of the CHANNEL effect in the original three models. Instead of a strong influence of a nonsocial economic force, we must interpret the original CHANNEL effect as partly a social effect itself, linked to wealth and caste-based inequality. This interpretation is further supported by anecdotal evidence on the nature of Dalit livelihoods.

Responses to the survey question "How does your caste affect you?" provide an incisive view of the lives and status of Dalit villagers in the region. A Dalit man in Keelanavayal interviewed in his house mentioned that the village justice system is very strict. If anyone makes a mistake, the village headmen will offer advice, and if that advice is not followed,

**Table 6.** AICc multimodel selection results. Akaike weights and coefficients for five logistic regression models predicting CHANNEL distribution. The last two columns on the right provide model weighted average coefficients and relative variable importance measures for each variable (Burnham and Anderson 2002). The inequality model captured the largest Aikaike weight, and best explains the distribution of irrigation channels.

| | Inequality | Individual | All | Base | Village | Model weighted average | Relative variable importance |
|---|---|---|---|---|---|---|---|
| weight | **0.97** | **0.01** | **0.01** | **0.00** | **0.00** | | |
| AICc | 258.2 | 266.6 | 266.8 | 318.5 | 319.4 | | |
| df | 6 | 8 | 12 | 2 | 6 | | |
| LNPOP | - | - | 0.13 | - | 0.01 | 0.00 | 0.01 |
| DISTANCE | - | - | 0.02 | - | 0.01 | 0.00 | 0.01 |
| CASTES | - | - | 0.01 | - | 0.09 | 0.00 | 0.01 |
| WEALTHGINI | -0.08 | - | -0.07 | - | -0.03 | **-0.08** | **0.99** |
| AGE | - | 0.01 | 0.02 | - | - | 0.00 | 0.03 |
| EDUC | - | 0.06 | 0.07 | - | - | 0.00 | 0.03 |
| HHSIZE | - | -0.07 | -0.07 | - | - | 0.00 | 0.03 |
| LNWEALTH | 0.53 | 0.54 | 0.52 | - | - | **0.53** | **1.00** |
| DALIT | -1.50 | -1.28 | -1.24 | - | - | **-1.49** | **1.00** |
| FRAC | 1.39 | 0.73 | 1.65 | - | - | **1.39** | **1.00** |

they will be beaten. This sort of response was not uncommon, but during the interview a neighbor kept urging the farmer not relate these facts out of fear of being exposed and punished. Another Keelanavayal Dalit expressed the same dismay over oppression in his village.

> *We must go to Kukkal [a different village] to borrow or rent equipment, no one will share with us here. Only other SC [Dalits] will trade labor with us, no one else. We are treated very badly here. Any problem is cause for the high caste people to beat the SC [Dalits].*

A Dalit farmer in Kumbur related that he prefers not to have a channel connection and the associated contact with the irrigation system because he is afraid of beatings from high caste people. These responses contrast markedly from the typical non-Dalit response, recorded verbatim many times, “Caste causes no problems for us.” In many cases non-Dalits actively noted their own caste rank, “We are high caste, so we have no problems here.” A Dalit farmer from Poombarai related that the high castes restrict the education of Dalits, and a Dalit man from Keelanavayal confirms the pattern.

> *Sometimes high caste people treat us very badly. That is, we depend financially on high castes, the government does not give us proper support, and the high caste people restrict SC [Dalit] education.*

A Dalit farmer from Pallangi describes some of the myriad types of restrictions on Dalit life.

> *We are not allowed to speak in Podhu Kootam [village council meetings]. The village people will not solicit money from SC people for temple improvement work. In this village SC people do not have land for irrigation.*

These excerpts contrast bitterly with the perspective of individuals who belong to powerful castes, such as a Manadiar man from Poombarai, “We share water, but the SC and ST [Dalits] are not allowed.”

Given these sorts of reports, and the rarity with which new channels are created (no interviewee reported channels being created more recently than 20 year ago), a likely interpretation is that caste-driven inequities are embedded in the channel distribution itself, rather than in the water distribution those channels provide, a pattern which has been detected by qualitative ethnographic work on elite privilege and water access (Mosse 2006). Model selection results and survey evidence on Dalit discrimination support Hypothesis 2 – ethnic dominance damages collective action efforts.

## DISCUSSION

These results reveal a larger scope for interethnic relationships than previous studies of collective action in common pool resources scenarios have observed. In particular, the three variables of central concern, CASTES, DALIT, and FRAC describe three dimensions of ethnocentric cooperation, and tell a clear story of how ethnic effects influence cooperation and collective action in real-world economic institutions.

First, in the regression analysis, increasing caste diversity (CASTES) decreases cooperation markedly, and is associated with a reduction in fairness. Although this finding parallels the literature in development economics on the influence of

**Table 7.** CHANNEL effect size calculations. Effect sizes are calculated as $e$^($d$•$C_{MWA}$), where $C_{MWA}$ = model weighted average coefficient, and $d$ = real world difference. Appendix Table A8 presents the original workdays regression and a modified regression with an inequality-adjusted CHANNEL variable. Not surprisingly, the inequality-adjusted CHANNEL workdays regression results are very similar to the original results, suggesting that even when social and wealth inequalities influencing CHANNEL distribution are accounted for, being connected to the irrigation systems still matters.

| | Difference | Description | Model weighted average coefficients | Effect Size (percent change) |
|---|---|---|---|---|
| WEALTHGINI | 0.27 | Difference between Keelanavayal (0.39) to Palangi (0.66) | -0.08 | 0.98 (-2%) |
| LNWEALTH | 2.30 | 100,000 more rupees | 0.53 | 3.41 (341%) |
| DALIT | 1 | Being Dalit | -1.49 | 0.23 (-77%) |
| FRAC | 0.5 | Increasing the size of ones caste to 50% of the village population | 1.39 | 2.00 (200%) |

ethnic diversity on public goods, it is a new result for studies of collective action in common pool resources (CPRs). It is unlikely that these new results are due to a fundamental difference in the requirements for collective action between CPRs and public goods, because those two domains are very similar as arenas for collective action. Instead it may be that regional public goods research has detected ethnic diversity effects because such studies can draw on large populations and may have better resolution for detecting ethnic effects than CPR studies, which often involve smaller populations.

Demographic dominance forms a second dimension of ethnically moderated cooperative behavior. Demographic dominance refers to the proportion of the village population represented by the respondent’s own caste group (FRAC). I found that as demographic dominance increased, so did cooperation and perceived fairness in irrigation. That individual cooperation decreases with increasing numbers of groups, but increases with the size of one’s own group matches expectations from ethnic psychology (Gil-White 2001), and presents a new twist on the “cultural homogeneity” result of Wade and others. Specifically, ethnic diversity, and conversely, ethnic homogeneity, is a function of both the number of castes and their relative size. In this paper these have been treated as separate aspects with separate predictor variables, but the two dimensions have been formally integrated by ecologists in indices such as the Shannon index (Shannon 1948). The Shannon index integrates two components of diversity, the number of groups (‘richness’) and the size equality of groups (‘evenness’) mathematically. My results suggest that such an index, properly calibrated, might provide a very useful instrument for making predictions of societal-level cooperative efforts, because it incorporates both dimensions.

The third dimension of ethnocentric cooperation is that of ethnic dominance. Ethnic dominance or ethnic ranking is a condition in which status, roles, wealth, and power are unequally split between ethnic groups (Horowitz,2000). I measured Dalit status (DALIT) in the current study as an individual marker of discriminatory ethnic inequality or ethnic dominance. Ethnic dominance can be difficult to perceive and hard to measure. In the regression results, the oppressed group of Dalits rated the adequacy of the cooperative irrigation system as highly as non-Dalits, and contributed as much labor to irrigation projects as non-Dalits. Thus, even in hierarchical societies it is difficult to detect the effects of ethic dominance through survey instruments. However, evidence of ethnic dominance comes from the analysis of irrigation channel distribution, which showed that the distribution of irrigation channels themselves was explained in part by ethnic inequality factors. In essence, being wealthy, belonging to a populous caste, and being non-Dalit makes a farmer many times more likely to have irrigation access at all. The influences of ethnic dominance were difficult to detect because they determined and were embedded in the water distribution system rather than flowing through it, as I had expected.

Extending these results to practical application is challenging because these results are novel and we require more case studies to appreciate the influence of context. Still, if the results are valid, villages in the Palani Hills region might be able to improve participation in and perceptions of village irrigation networks were they extended equally to residents regardless of caste. The same statement is likely true for other village-wide cooperative institutions as well. These results give us little guidance, however, on how to address the negative influence of ethnic diversity or to reduce the ethnic inequality and dominance.

## CONCLUSION

Prior studies of common pool resource management have found little evidence of ethnic effects on collective action, and those that do typically treat cultural or ethnic effects as a single dimension, i.e., homogeneity, or ‘social capital.’ However, evolutionary anthropology provides a more intricate model of the determinants of cooperation, and I have measured and analyzed three separate ethnic effects on cooperation relevant to the anthropological theory here, namely ethnic dominance, and two dimensions of ethnic diversity, i.e., number of groups and relative sizes of groups.

Because caste is uniquely differentiated and hierarchical, it may be easier to detect ethnic effects in India than in other societies. Nonetheless, Indian caste is a special case of ethnic identity, and the anthropological theories of cooperation are very general, and suggest that such mechanisms operate in all populations. So, in any multiethnic region, two separate but related factors of cooperation need to be addressed beyond the standard socioeconomic predictors; (1) the amount of shared social identity, which declines with increasing group numbers and increases with population skew between groups, and (2) ethnic inequalities in power, status, roles, and wealth. These factors can, at least in some cases, be distinguished from the ecological and economic drivers, and may prove very influential in determining social outcomes across societies and at multiple scales.

Many questions remain. Does ethnic diversity or ethnic dominance cause greater reductions in cooperation? A robust and general answer to this question would help in practical applications by clarifying the cooperative factor of primary importance. Can institutions be structured so that multiethnic societies do not pay a cooperative cost for being diverse? Can institutions be structured so that ethnic differences do not generate ethnic inequalities and lead to the injustice and inefficiencies of ethnic dominance? These questions can only be addressed through rigorous, quantitative, cross-cultural research.

*Responses to this article can be read online at:*
*http://www.ecologyandsociety.org/vol16/iss4/art1/responses/*

**Acknowledgments:**

*I thank the farmers in Vilpatti, Palangi, Poombarai, Manavanur, Kumbur, and Keelanavayal, as well as V.P. Vetrivel for assistance, Mark Lubell for guidance, and Mark Grote for statistical advice. I have no conflicts of interest. This research was supported by the National Science Foundation, Award # BCS0823416.*

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[1] Keelanavayal (top 20% most wealthy own 60% of total wealth) to Pallangi (top 20% most wealthy own 80% of total wealth).

# APPENDIX

This Appendix provides additional ethnographic information, population characteristics, sampling information, predictor and response variable details, and supplemental analyses.

## Palani Hills Ethnography

These villages, originally settled by the Manadiar group, retain traditional governance institutions separate from the official government panchayat system. The similarity of these institutions to those on the Tamil plains (Mosse, 2006), oral tradition, and historical evidence (Francis, 1914, Bahadur and Aiyangar, 1942) all suggest that they are a cultural legacy of the Pandiya kingdom that the Manadiar brought with them when they migrated into the hills approximately six centuries ago (Francis, 1914).

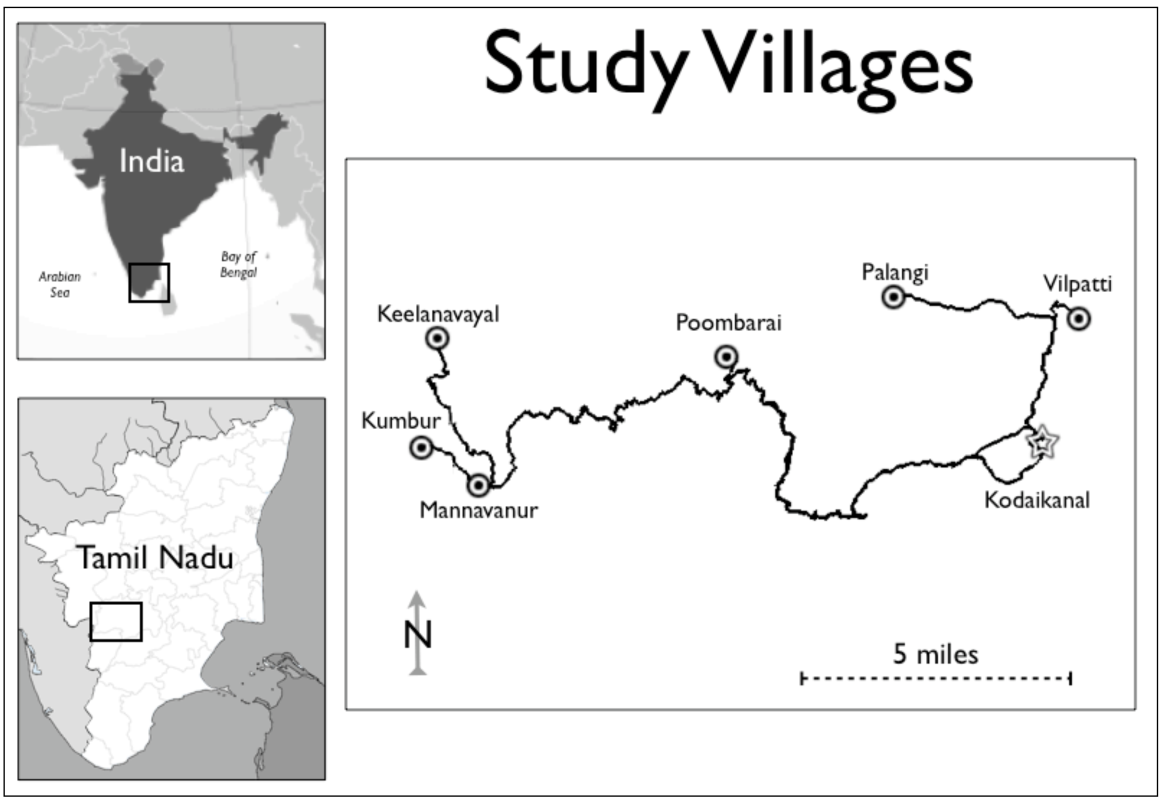


**Figure A 1. Study villages in the Palani Hills, Tamil Nadu, India.**

Five months of ethnographic investigation on the social identity, oral history and village organization across the Upper Palani villages form the basis by which caste relationships were classified. Villages in the Palani hills region employ a traditional village organization system. Two central traditional institutions are the *podhu kootam* (village council), and *neer nikam* (village irrigators). In these villages most official roles are ascribed to by caste.

Caste structure in the Palani Hills region is centered on two focal caste groups at opposite ends of the power spectrum, which share a long history. The Manadiar caste are in the center of village power; in most villages the Manadiar hold some or all of the hereditary leadership positions called *thalaivarhal* (literally, 'headmen'), and their influence within the village justice system or Podhu Kootam ('common crowd'). By contrast, the Sakkliyar, a Dalit group which shares a deep history with the Manadiar, having arrived around the same time as the Manadiar, have no formal power. For instance, women and Sakkliyar individuals are excluded from the semi-sacred village commons called the *manthai* where village meetings are held, and thereby physically blocking access to the space of village justice.

Leadership positions in the Palani Hills villages called *thalaivar*, or 'headman' are individually named, with multiple thalaivarhal per village. Common thalaivar titles include Manadiar (named for the founding caste), Manthiriar (sacred), and Periyathanam ('large wealth'). For instance, in Poombari (one of the six study villages) the Manadiar position is occupied eponymously, while two further *thalaivar* positions are occupied by the Thevar (*Periyathanam*) and the Mudhaliar (*Manthiriar* ) elders. The Sakkliyar also bear traditional village servant positions, including the village crier (*thandalkarar*), the water controller (*neer-nikam*), and the festival celebrant (*vettiyan*). No middle castes hold any high-status or low-status traditional roles. These formal roles betray the historical caste-driven power asymmetry, and are summarized in Table 1.

In Palani Hills villages the traditional village leaders or *thalaivar* (literally, headmen) positions are occupied by the Manadiar, a historically dominant jathi, and secondary *thalaivar* positions (such as *Periyathanam, Manthiriar, Maniyakarar, Kariyamanadi, and Pattakarar*) are occupied by men from other powerful jathis.

| | Poombarai | | Mannavanur | | Kumbur | | Keelanavayal | | Vilpatti | | Pallangi | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thalaivarhal (leadership positions, inherited) | | | | | | | | | | | | |
| *Manadiar* | 1 | Manadi | 3 | Manadi | 5 | Asari | 3 | Asari | 4 | Manadi | 1 | Manadi |
| *Manthiriar* | 1 | Mudali | 1 | Pillai | 1 | Chetti | 1 | Mudali | 2 | Pillai | 1 | Mudali |
| *Other** | 1 | Thevar | 1 | Manadi | 1 | Chetti | 1 | Reddi | 1 | Retti | | |
| Servant (servant positions, selected) | | | | | | | | | | | | |
| *Thandalkarar* | 3 | Dalit | 1 | Dalit | 1 | Dalit | 1 | Dalit | 1 | Dalit | 1 | Dalit |
| *Neer Nikam* | 4 | Panchayat | 5 | Dalit | 3 | Dalit | 2 | any | 3 | any | 0 | Thandal |
| *Vettiyan* | 20 | Dalit | 13 | Dalit | 15 | Dalit | 8 | Dalit | 16 | Dalit | 10 | Dalit |

**Table A 1. Traditional village positions in the six study villages, by caste occupancy.** Sakkliyar is the major Dalit caste in the Palani hills region. Servant positions are selected by the thalaivar ('headmen') for 1-3 yr terms *Other = Village specific thalaivar postions, including Periyathanam (wealthy leader), Maniyakarar, Kariyamanadi, Pattakarar, and Mem-, Chola-, Shantha-, Karu-manadi.

## *Population characteristics*

Of the surveyed heads of households, the average age was 46.7 with the youngest 19, and the oldest 87. The mean household size was 4.5 and the average years of education of the household head was 4.9, but over one quarter reported zero years of education, while one person reported 17 years. Of all household heads, four were women, and only 2% reported any additional occupation to farming.

The cost and availability of transport makes these villages very isolated. As a result many factors decline with the distance from Kodaikanal, including the mean years of household education. Mean household education starts from 6.7 yrs on average in Vilpatti, and declines by approximately one month per kilometer over the 44 miles to Keelanavayal, where the mean is 3 yrs lower on average (single correlation, $R^2 = 0.16$). Similarly, yearly exposures to external culture (see Table 3 for variable description) shows a similar pattern starting from ~1500 yearly exposures in Vilpatti and Pallangi and effectively dropping nearly 16 exposures per mile to reach a yearly 803 exposures in Keelanavayal. Such a difference in exposure likely has a strong influence on the social norms of the people living in these villages. Agricultural income also declines with distance from Kodaikanal, dropping 66 Rs. from Vilpatti to Keelanavayal, a 30% reduction in daily pay.

In this region, aside from plowing with oxen, the agricultural enterprise is exclusively manual. Out of necessity, this splits individuals on any given day into the land owners and workers, or 'coolies'. All individuals work on their own fields, if they own any, and 76% work on others fields as well. 94% of Dalits work as coolies, in comparison to 77% of Manadiar. On the hiring side, only 51% of Dalits hire others to work on their fields, while 92% of Manadair hire our their work. As a result, Dalits on average earn 7,660 Rs per year from coolie labor, while Manadiar average only 4,900 Rs. On average, dalits hire 194 worker-days of labor per year, while Manadiars hire 480 worker-days, well over double the Dalit figure. These caste-correlated inequalities are also born out in land ownership and wealth.

Villagers owned an average of 2.3 acres, with 1.31 acres of irrigated land. Mean Dalit land holding was 0.46 acres, while Manadiars owned 4.45 acres on average. Of the 45 households owning no land, 58% were Dalit. Of the 14 individuals owning five 5 or more acres all are middle and high castes. A comprehensive wealth estimation was calculated based upon items such as house, land, livestock and vehicle ownership (see table 3). Mean wealth was 398,790 Rs. for Dalits and 1,270,730 Rs. for Manadiar.

Each farmer was asked to rank the importance of six factors in determining their social identity. These factors were family, caste, religion, political parties, hometown, and occupation. There was a very clear trend in preferences within the entire sample. Out of a total of 6 points, family averaged 5.9, followed by occupation (5.0). The remaining categories had overlapping confidence regions but were as follows hometown (3.5), caste (2.6), religion (2.4), political (2.1). The clear, sample wide preference for family and occupation is relevant to the current study because caste was not even close to being a highly ranked component of reported social identity factors.

| Village | population | households | castes | 10+ house hold castes | n | average caste-wise household sample |
|---|---|---|---|---|---|---|
| Mannavanur | 5029 | 762 | 8 | 4 | 43 | 33% |
| Poombarai | 4456 | 1262 | 11 | 8 | 69 | 14% |
| Vilpatti | 2032 | 508 | 10 | 6 | 58 | 13% |
| Kumbur | 1051 | 208 | 5 | 3 | 33 | 18% |
| Keelanavayal | 700 | 104 | 8 | 2 | 30 | 44% |
| Pallangi | 700 | 133 | 3 | 3 | 26 | 33% |

**Table A 2. Sampling strategy.**

| | Keelanavayal | Kumbur | Mannavanur | Pallangi | Poombarai | Vilpatti | Sample |
|---|---|---|---|---|---|---|---|
| *workdays* | 4.10 | 1.39 | 5.88 | 1.58 | 2.49 | 2.86 | 2.68 |
| | (11.66) | (2.22) | (8.33) | (1.30) | (1.59) | (1.78) | (2.86) |
| *adequacy* | 2.23 | 1.06 | 2.16 | 1.92 | 2.11 | 2.00 | 1.97 |
| | (1.61) | (1.03) | (1.38) | (1.72) | (1.52) | (1.51) | (1.50) |
| *fairness* | 3.40 | 2.35 | 3.60 | 0.65 | 2.56 | 2.69 | 2.64 |
| | (1.75) | (2.22) | (1.76) | (1.50) | (2.17) | (1.98) | (2.10) |

**Table A 3. Response variable summary statistics.**

| | *Workdays* | *Adequacy* |
|---|---|---|
| *Workdays* | | |
| *Adequacy* | *0.02* | |
| *Fairness* | *0.17* | *0.25* |

**Table A 4. Response variable correlations calculated using restricted maximum likelihood.**

| | *Population (households)* | *Distance (km)* | *Castes (>10 hh)* | *Wealth Gini* |
|---|---|---|---|---|
| Keelanavayal | 104 | 44 | 2 | 0.39 |
| Kumbur | 208 | 39 | 3 | 0.46 |
| Mannavanur | 762 | 36 | 4 | 0.45 |
| Pallangi | 133 | 10 | 3 | 0.66 |
| Poombarai | 1262 | 18 | 8 | 0.49 |
| Vilpatti | 508 | 5 | 6 | 0.43 |

**Table A 5. Village-level predictor and control variables.**

| | *Wealth Gini* | *Distance* | *Population* | *Castes >10* | *Castes All* |
|---|---|---|---|---|---|
| Wealth Gini | | | | | |
| Distance | -0.35 | | | | |
| Population | 0.01 | -0.24 | | | |
| Castes >10 | 0.02 | -0.60 | 0.89 | | |
| Castes All | -0.52 | -0.30 | 0.75 | 0.81 | |
| ***Diversity H'*** | ***-0.49*** | ***-0.45*** | ***0.68*** | ***0.82*** | ***0.90*** |

**Table A 6. Village-level predictor variable correlations.** Population and caste numbers are highly correlated. This is an inescapable feature of population structure in the study region. Larger villages are not necessarily more diverse, but more diverse villages are always larger. Diversity H' represents the Shannon index calculated for caste diversity, included here for reference.

| | *Workdays* | *Adequacy* | *Fairness* |
|---|---|---|---|
| *Family* | *neg. binom.* | *binomial* | *binomial* |
| coefficient | ***-1.53*** | ***0.10*** | 0.22 |
| p value | ***0.01*** | ***0.09*** | 0.01 |
| Adjusted $R^2$ | ***0.02*** | ***0.01*** | 0.03 |

**Table A 7. Population-adjusted response correlations.** Single linear regressions of each population-adjusted response variable against the population-adjusted caste diversity variable produce a simple measure of the population-adjusted effect of caste diversity on each response variable. The presence of additional caste information is evident in each case. *Italics* indicate that the direction of the diversity effect agrees with the corresponding multiple regression in the text. Boldface indicates which multiple regression found caste diversity to be a significant effect.

**(a)**
**Inequality-Adjusted**
**Workdays Model**

| | Estimate | SE | z | p | |
|---|---|---|---|---|---|
| (Intercept) | -1.41 | 0.83 | -1.70 | 0.088 | . |
| LNPOP | 0.80 | 0.15 | 5.22 | 0.000 | *** |
| DISTANCE | -0.01 | 0.01 | -2.19 | 0.028 | * |
| CASTES10 | -0.27 | 0.08 | -3.59 | 0.000 | *** |
| WEALTHGINI | -0.03 | 0.01 | -2.89 | 0.004 | ** |
| AGE | 0.00 | 0.00 | -0.29 | 0.776 | |
| EDUYRS | -0.01 | 0.02 | -0.38 | 0.704 | |
| HHSIZE | 0.06 | 0.04 | 1.28 | 0.201 | |
| LNWEALTH | 0.03 | 0.03 | 0.79 | 0.429 | |
| FRAC | 1.19 | 0.44 | 2.70 | 0.007 | ** |
| DALIT | -0.08 | 0.16 | -0.51 | 0.609 | |
| CHANFIX | 0.16 | 0.07 | 2.28 | 0.022 | * |
| DALIT:CHANFIX | 0.01 | 0.14 | 0.06 | 0.953 | |
| Residual deviance: 310 on 241 degrees of freedom | | | | | |
| AIC: 1060.4 | | | | | |

**(b)**
**Non-adjusted**
**Workdays Model**

| | Estimate | SE | z | p | |
|---|---|---|---|---|---|
| (Intercept) | -1.58 | 0.83 | -1.90 | 0.057 | . |
| LNPOP | 0.77 | 0.15 | 5.03 | 0.000 | *** |
| DISTANCE | -0.01 | 0.01 | -2.15 | 0.032 | * |
| CASTES10 | -0.26 | 0.08 | -3.44 | 0.001 | *** |
| WEALTHGINI | -0.03 | 0.01 | -2.38 | 0.017 | * |
| AGE | 0.00 | 0.00 | -0.30 | 0.765 | |
| EDUYRS | -0.01 | 0.02 | -0.34 | 0.737 | |
| HHSIZE | 0.06 | 0.04 | 1.32 | 0.187 | |
| LNWEALTH | -0.01 | 0.04 | -0.38 | 0.705 | |
| FRAC | 1.14 | 0.44 | 2.58 | 0.010 | ** |
| DALIT | -0.03 | 0.23 | -0.15 | 0.885 | |
| CHANNEL | 0.38 | 0.17 | 2.17 | 0.030 | * |
| DALIT:CHANNEL | 0.12 | 0.31 | 0.38 | 0.703 | |
| Residual deviance: 310 on 241 degrees of freedom | | | | | |
| AIC: 1060.0 | | | | | |

**Table A 8. CHANNEL-inequality-adjusted workdays regression comparison.** Workdays negative binomial regression replicated with (a) and without (b) adjusted channel variable. CHANFIX is the inequality-adjusted version of the CHANNEL variable, ie the residuals of the AIC best fit model explaining CHANNEL distribution. Note that the changes in estimates and probabilities are small, and that CHANFIX remains and important explanatory factor, even when the embedded aspects of social inequality are removed. Other CHANNEL-inequality-adjusted regressions showed similar patterns.