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Natural resource collection and desired family size: a longitudinal test of environment-population theories

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Abstract

Theories relating the changing environment to human fertility predict declining natural resources may actually increase the demand for children. Unfortunately most previous empirical studies have been limited to cross-sectional designs that limit our ability to understand links between processes that change over time. We take advantage of longitudinal measurement spanning more than a decade of change in the natural environment, household agricultural behaviors, and individual fertility preferences to reexamine this question. Using fixed-effects models, we find that women experiencing increasing time required to collect firewood to heat and cook or fodder to feed animals (the dominant needs for natural resources in this setting) increased their desired family size, even as many other macro-level changes have reduced desired family size. In contrast to previous, cross-sectional studies we find no evidence of such a relationship for men. Our findings regarding time spent collecting firewood are also new. These results support the "vicious circle" perspective and economic theories of fertility pointing to the value of children for household labor. This feedback from natural resource constraint to increased fertility is an important mechanism for understanding long term environmental change.

Keywords

Fertility; natural resource use; fodder; firewood; Nepal; intentions; family size

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From at least the time of Malthus to today's UN Sustainable Development Goals the environment-fertility relationship has been seen as crucial to understanding long term environmental changes. Though there is general acknowledgement of the reciprocal nature of this relationship and some advanced modeling of feedback loops (de Sherbinin et al. 2007; Zvoleff and An 2014), we know relatively little about the effects of environmental change on fertility from longitudinal studies of the same people over time. This paper revisits a classic question in population-environment: how does a change in the natural environment change individuals' fertility?

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Theories yield contrasting hypotheses. Malthus predicted families will respond to increasing scarcity of natural resources by avoiding childbearing, and many scientists continue to agree with this perspective. Others predict that increasing scarcity of natural resources will increase the value of children, promoting a "vicious circle" in which scarce resources increase childbearing and increasing childbearing makes resources even more scarce. The existing empirical evidence has been unable to adjudicate between these two perspectives. One reason may be that both mechanisms do play a role, with the strength of each depending on local circumstances. Another reason may be mis-specified modeling, for example ignoring macro-level changes in social organization that make it possible to support more dense populations within fixed resource constraints (Lam 2011). A third reason may be that prior cross-sectional studies provide no opportunity to untangle potential reciprocal causation. We take advantage of a data source with longitudinal measures over more than a decade documenting the natural environment, local community resources, household practices, and individual fertility desires to estimate causal models and move our knowledge of this relationship forward.

We conceptualize environmental change specifically in terms of natural resource extraction for household use and focus on changes in individuals' desired family size as the outcome. We use recently available measures from the Chitwan Valley Family Study (CVFS) to revisit previous cross-sectional research with this new multilevel long term longitudinal measurement. In this setting the highest demand for natural resources is firewood to heat and cook and fodder to feed animals. Using the CVFS data we document that increasing local scarcity of these key natural resources actually promotes changes toward demand for more children for women. This result is all the more startling and important because it is measured within the context of overall rising resources and declining demand for children.

Theories predicting a positive relationship: decreasing access to natural resources leads to <u>decreasing</u> fertility desires

Neo-Malthusian approaches to the population-environment relationship are some of the most commonly cited in the public (most notably Ehrlich 1968). These include arguments that the primary way to achieve sustainability is by decreasing population growth (Brander 2011) but generally focus on the effects of fertility on the environment. When considering the reverse relationship this perspective posits that a decline in the environment puts strain on households, they respond to this strain by decreasing their demand for children and implementing necessary behavioral constraints (e.g. abstinence and delayed marriage according to Malthus). In agricultural settings highly dependent on local forest products this perspective predicts that declining access to forest resources should generate declining demand for children and reduced childbearing. We do have some empirical evidence supporting a positive environment-fertility relationship. For example, research demonstrates that even within rural areas when more land is devoted to agriculture than to other purposes fertility is higher and marriage occurs earlier, which itself could lead to higher fertility (Bhattacharya and Inness 2008; Grace and Nagle 2015; Yabiku 2006).

However, general theories linking broader social change and fertility behavior yield a similar prediction when applied to agricultural settings dependent on forest products. For example, consider the modes of social organization framework. Empirical research derived from this framework yields overwhelming evidence that the growth of non-family organizations is related to lower demand for children and to lower fertility (Axinn and Yabiku 2001; Behrman 2015; Brauner-Otto et al. 2009; Entwisle, et al. 1996; Miller and Babiarz 2016; Thornton and Lin 1994). These local community changes lead to lower desired and actual family size through a variety of mechanism such as increasing opportunity costs for women via education and employment, improved child survival, and the introduction of new, particularly Western, ideas (e.g. Axinn and Yabiku 2001; Caldwell 1982; Entwisle et al. 1996; Grimm, Sparrow, and Tasciotti 2015; Miller and Babiarz 2016; Thornton and Lin 1994).

However, the growth in non-family organizations such as schools, markets, employers, and Western health services increases the built environment often by converting common land out of forest use thereby reducing access to natural resources (Shivakoti et al. 1999). So, even as natural resources are becoming more scarce, transportation, trade, and rising incomes give rural residents more total access to resources. To the extent then that these community changes result in a decrease in access to natural resources we would expect to observe a positive relationship between natural resource availability and fertility, though because of other mechanisms, not through the mechanism of declining access to natural resources. In fact, empirical research combining measures of land use with measures of local social organization found that a greater proportion of land in a neighborhood devoted to agriculture was associated with higher fertility, but that that effect was not independent of the non-family services available (Ghimire and Axinn 2010; Ghimire and Hoelter 2007). Furthermore, changes in local community context in terms of social services have independent effects on both fertility behavior and land use, conditioning the observed associations between fertility and land use (Axinn and Ghimire 2011).

An additional concern that arises is if, as is likely the case here, one direction of the hypothesis (e.g. fertility effects on resource use) is quite strong. Cross sectional designs, which are what are commonly available, prevent adjudication of this potential reciprocal causation. Without multilevel longitudinal measurement that controls for change over time in community context it is relatively easy to mis-specify observation of micro-level associations between scarcity of forest resources and fertility. This issue may be problematic for both individual- and macro- level studies because both rarely have measures of the myriad of changes occurring simultaneously or the ability to assess reciprocal relationships. In sum, there is little robust empirical support for these neo-Malthusian arguments, but analysis using multilevel, longitudinal data, as we are able to use here, may yield a different conclusion.

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Theories predicting an inverse relationship: decreasing access to natural resources leads to increasing fertility

Theories positing an inverse relationship between the environment and fertility typically hinge on the value of children. A cost-benefit model of fertility (Easterlin and Crimmin 1985) as well as the vicious circle argument (Filmer and Pritchett 2002; O'Neill, MacKellar, and Lutz 2001) hold that the demand or desire for children is determined by their contributions to household labor and this demand then motivates fertility behavior. A change in children's actual or expected contributions to household labor would then change parents' demand for children (i.e. their desired family size). Setting specific differences in the degree to which these household contributions determine the value of children have the potential to generate high variance in this prediction, with cultural norms and personal preferences also relevant (de Sherbinin et al. 2008). For example, in societies in which children are legally prevented from certain types of labor or household economic activity this value of children may be greatly reduced, also reducing the strength of this mechanism. Application of these economic models is most successful in poor, agrarian societies where children typically do contribute substantially to household functioning, particularly by gathering natural resources such as fodder and firewood or by doing other household tasks thereby freeing adults, particularly women, to gather resources (Cain 1977). In such a setting this perspective predicts that declining access to natural resources will increase this gathering time, increasing the value of children, leading to an increase in the demand for children.[1]

We have empirical evidence in support of this theoretical perspective from a variety of settings. For example, Filmer and Pritchett (2002) found that in some areas in Pakistan households that are farther away from wood sources were more likely to have had a recent birth. Aggarwal et al. (2001) found a similar relationship for rural households in South Africa. Using data from the first wave of the CVFS, Biddlecom et al. (2005) found that respondents who thought they currently spent at least an hour longer collecting firewood than they had three years ago had a higher odds of giving birth and women who reported a similar increase in time to collect fodder desired larger families. However, all of these studies used cross-sectional data and, in acknowledging the methodological limitations for drawing causal conclusions from such data, have called for additional analyses using longitudinal data. As explained above, longitudinal measures can be particularly valuable in adjudicating between these theoretical predictions because the effects of fertility on natural resources may be so strong that cross-sectional analyses mis-state the reciprocal effects of natural resources on fertility.

[1]Note, this prediction assumes that when natural resources diminish households cannot readily substitute other goods, such as purchased fuel, for those previously gathered. That is, the specific local social organization may condition this relationship. In poor, agrarian societies like Nepal this assumption is reasonable. However, in other settings, where markets are more accessible in terms of household finances and location, households may substitute alternatives for local forest products. This may allow households to support the same size or smaller family with fewer resources and children may be less desired because there is less need for their labor (see Brauner-Otto 2014 for more on this and other pathways and conditions).

Testing these Hypotheses

Constructing tests of these hypotheses presents significant empirical challenges. First, although theoretically motivated by questions of change, most existing research has not been able to estimate models of change. At best they may use subjective measures of environmental change (e.g. using responses to questions asking whether respondents think their environmental conditions have changed) but do not have measures of change in fertility. This data limitation is important because: a) theories in this domain were designed to predict change over time, not cross-sectional variation, b) individual subjective assessment of change is known to be inaccurate, and c) design of policies to address environmental changes requires strong prediction of likely consequences across time. Second, as described above, the potential for spurious relationships is high since both the natural and built environment are changing at the same time. Because these multiple, contrasting dynamics of change occur simultaneously it is difficult to isolate the effects of environmental changes producing reduced access to natural resources.

Long term, multilevel longitudinal data resources like the Chitwan Valley Family Study (CVFS) allow us to address some of these limitations. The CVFS was launched in the mid-1990s and tracked communities, households and individuals through the present day. Important for this study, it has longitudinal measures at the environmental, community, household, and individual level allowing us to isolate the relationship between declining access to key natural resources and change in the demand for children in a context of rising resources and overall declining fertility. The combination of multilevel (which allows us to address the changing broader community context, an issue we discussed above) and repeated measurement of the same people and communities over long spans of time provides the key data needed.

Of course, longitudinal data have their own issues, chief among them is attrition. All longitudinal studies are vulnerable to the possibility that respondents drop out at later rounds leaving a select group of respondents available for analysis. However, the CVFS was executed with state-of-the-art survey methods for controlling attrition, including multiple interviews per household, frequent contact with household members, and mixed-mode data collection that evolved over time as technologies changed. The result has been unusually high success in controlling attrition, with 95% of the sample remaining in the study across two decades (Axinn, Ghimire and Williams 2012). This is particularly important here because though other longitudinal data sources exist, migrants are often excluded from follow-up rounds. Because natural resource availability is linked to migration (Hunter et al. 2014; Piotrowski, Ghimire, and Rindfuss 2013), excluding migrants biases results and masks the true effect of the access to natural resources on individuals.

Another related methodological issue is exit from resource use for those remaining in the study. Changes in time for resource extraction can only be measured for households that are currently using that resource. Because resource extraction time may be related to the (dis)continued use of a resource, the exclusion of those no longer using the resource can bias the results. Because the CVFS includes detailed questions regarding exit from use of resources – switch to alternative fuels to cease firewood collection or abandoning animal husbandry to cease fodder collection – we are able to include those who discontinue using the resource in our analysis. This allows us to examine the potential effect of this household response – cessation of using the resource – on estimates of the consequences of reduced access to resources.

Setting

We investigate the relationship between natural resource extraction and desired family size in Chitwan, Nepal—an ideal setting for both environmental and demographic reasons. Chitwan is located in the Terai region of Nepal in the central foothills of the Himalayas and at the confluence of one of the three main drainage systems in the central Himalayas. It is surrounded on three sides by forest land, including the Royal Chitwan National Park (a wildlife reserve and UNESCO World Heritage property). Plant diversity is a crucial component of the environment in this area but is currently threatened (Lehmkuhl 1994; Peet et al. 1999). For example, *Mikania micrantha*, a plant which is not usable or edible by native animals and people, has been identified in the area, crowding out native plants, making the area less diverse and less stable (Poudel et al. 2005).

Until the 1950s, Chitwan was covered with virgin jungle and thinly inhabited by indigenous ethnic groups. In the 1950s, the government began clearing parts of the jungle, implemented malaria eradication efforts, and instituted a resettlement plan leading to the in-migration of many different ethnic groups. Much of Chitwan today is fertile agricultural land. By the late 1970s, roughly two-thirds of this valley was cultivated and the first all-weather road was completed, linking Narayanghat (the main town in the study area) to India and eastern Nepalese cities. Subsequently, other major highways were constructed making Narayanghat a transportation hub for the entire country. This led to the rapid expansion of non-family organizations such as schools, health services, wage labor opportunities, and markets. These are not distributed evenly across the study area, and it may be that families who have better access to markets and wage labor opportunities are better able to substitute alternative fuels or animal food to cope with poor environmental conditions.

Even with these changes daily life is still heavily connected to the natural environment. Subsistence practices dominate and even shop owners and others employed in non-farm ventures typically have tight connections to the environment through livestock or fuel use for the home (Link, Axinn, and Ghimire 2012). In fact, about three-quarters of the neighborhoods in this study harvested and grazed animals in the surrounding forest areas of Chitwan Valley (Matthews, Shivakoti, & Chhetri 2000). Use of wood for fuel used in heating and cooking is similarly crucial for daily living, but clearly driven by separate needs. Households that do not have livestock may still gather firewood and those who have switched to alternative fuel sources likely still have at least some livestock. In the CVFS the correlation between time spent gathering fodder and time spent gathering firewood in 1996 was statistically significant but not high (Pearson correlation coefficient=0.11). Prior research in this setting demonstrates that this positive association derives from other household level factors linking numbers of animals to the numbers of people in the household (Axinn and Axinn 1984). Because of this, we treat the processes of collecting fodder and firewood as independent and our models account for these underlying factors.

In general, as in many poor, agricultural societies, women in Nepal are typically tasked with gathering fuel and fodder (Agarwal 1994; Bennet 1983; Link et al. 2012). However, there is variation across resources. In the CVFS data as a whole in 1996 women collected fodder in 95% of households but men did so in only 55% of households; women collected firewood in 85% of households but men did so in only 70%. These important gender differences in the burden of collecting natural resources mean that changes in access to resources may have different consequences for the fertility preferences of men and women, even husbands and wives. Additionally, women often do the majority of childcare and housework. Although men are also engaged in other labor activities, childcare and domestic responsibilities such as cooking can be delegated to older children if women need to spend more time gathering resources or tending to very young children. Men's tasks are often not as readily redistributed (Cain 1977).

Estimation of such gender differences is a long-standing shortcoming of demographic research, because until recently most studies of fertility only interviewed women (Watkins 1993). The CVFS measures exactly the same things from both men and women (including husbands and wives in separate, simultaneous interviews to promote independence of responses), providing the means to examine gender differences in these associations. Because women's labor activities are likely more sensitive to environmental changes and changes in family size we expect that their preferences may similarly be more sensitive to changes in time to collect the resource. However, the difference between men and women may be less when considering time to collect firewood because men are more involved in that labor.

As local community changes were happening, individual fertility behaviors were also changing in Nepal. The Total Fertility Rate dropped from over 6 in the 1960s to approximately 4.6 for 1994–96 and to 3.1 by 2006 (Ministry of Health [Nepal], New ERA & ORC Macro, 2007; Pradham et al. 1997). First births rapidly follow marriage and contraception, which was virtually nonexistent until the very recent past, is typically used to end childbearing not to space births (Axinn and Yabiku 2001; Ghimire 2003). Men and women's ideal family size in Nepal is relatively small: the mean ideal number of children was 2.9 in 1996 and 2.3 and 2.4 in 2006 among women and men, respectively (Ministry of Health [Nepal], New ERA & ORC Macro, 2007).

Data and Methods

The Chitwan Valley Family Study (CVFS) operationalizes the local community context as a neighborhood of contiguous households with a systematic sample of 151 neighborhoods in Western Chitwan Valley. Neighborhoods, or *tols*, are clusters of 5 to 15 households typically located at the intersection of rural roads. Services and organizations such as markets are also often located at these crossroads. All neighborhood residents between the ages of 15 and 59 and their spouses were interviewed in 1996 (baseline) and were re-interviewed in 2008 (follow-up). To avoid analyzing desired family size for those who have completed their fertility we focus on the 2276 individuals, 1254 women and 1022 men, under age 45 at follow-up (i.e. aged 15 to 33 at baseline) who were not missing data on our final analysis variables.[2]

The CVFS conducted household level interviews in 1996 and 2006—these are the basis for our measures of time for resource extraction. Individuals who moved out of their original, baseline, household were kept in the sample and a separate household level interview was conducted for that new household at follow-up. This means that multiple respondents from one household at baseline may be living in different households (with different resource conditions) at follow-up.

A final relevant component of the CVFS is the Neighborhood History Calendar (NHC) providing yearly information on non-family organizations present in the study area up to 2003 (Axinn, Barber, and Ghimire 1997). The NHC technique combines archival, ethnographic, and structured interview methods to gather detailed, continuous measures of neighborhood change over time. Information was gathered on the distance (in minutes walking) to the closest market, school, health service provider, and employer separately for each neighborhood-organization combination.

Of course, as with all empirical studies, the CVFS design also imposes limitations that limit the ways in which we can test key hypotheses. For example, the CVFS measures do not provide more frequent updates of changes in either time to reach natural resources, individual fertility preferences, or other community changes. With more frequent measures analysis could identify the specific timing of the association between changes in access to natural resources and changes in fertility preferences. The CVFS design forces us to take a longer term approach, investigation the association between these changes across a decade.

Desired family size

We investigate change over time in desired family size. Our measure comes from a set of questions designed by Lolagene Coombs (1974) to ascertain underlying family size preference. The first item in the Coombs Scale measure was: "People often do not have exactly the same number of children they want to have. If you could have exactly the number of children you want, how many children would you want to have?" Using this preferred number as a basis, the second item was: "If you could not have exactly [the number the respondent gave] children, would you want to have [one number lower] or [one number higher]?" Then for the third question: "If you could not have [the second choice number] of children, would you want to have [one number lower] or [one number higher]?" Figure 1 displays the options a respondent has when answering the Coombs Scale questions. Depending on the path a respondent followed in answering these questions, s/he is coded as somewhere between 1 and 25. This variable was measured for all respondents at baseline and follow-up. The median score at both waves for women is 6, corresponding to a preference for first 2 children, then 3 (as opposed to 1), then 1 child (as opposed to 4). Men have a preference for slightly smaller families—for instance, at baseline their median score was 5 denoting preference for 2 children, then 1 (as opposed to 3), then 3 (as opposed to zero).

Figure 2 shows the distribution of desired family size over time for women (Panel A) and men (Panel B). You can clearly see that there has been a trend toward smaller family sizes

[2]We estimated all models with respondents who were under age 45 at baseline and all effects were stronger than those shown here.

and a marked increase in a preference for two children. At baseline, a quarter of women and slightly less than 20% of men had a Coombs scale value of 6, but that percent had more than doubled by follow-up where 55% and 46% of women and men, respectively, had that preference pattern. There is also less variation in desired family size over this time as 75% of respondents reported a preference pattern value of 4 or 6 in follow-up but only 40% did so at baseline. This clustering appears to be largely at the expense of preference patterns 5 (2, 3, then 1 child) and 7 (2, 3, 4 or 3, 2, 1). The mean scores for both women and men decreased by about 0.25 (see Table 1 for descriptive statistics of all measures).

Figure 2 also reveals an additional benefit of using the more complex Coombs scale as opposed to a simple 1 question measure: we are able to see variation in desires even if the first preferred family size does not change. The Coombs Scale's multiple question strategy has been used successfully in a number of studies around the world including the U.S., Korea, Taiwan, Malaysia, Hungary, the Philippines, and Bogota (Coombs 1977, 1979; Coombs and Sun 1978). Individuals typically have a range of acceptable numbers of children, something that is masked by asking for one preferred number, and this scale reveals an individual's "potential or bias toward a larger or smaller family size" (Coombs 1979, pg. 26). We treat the Coombs Scale as an interval level measure.

Use of Local Natural Resources

Our main interest is use of local natural resources. In this setting historical studies clearly demonstrate that collection of fuelwood and fodder are by far the two largest types of natural resource use (Axinn and Axinn 1984). Using household level surveys conducted in 1996 and 2006 we create continuous measures of the time households devote to collecting natural resources, specifically fodder and firewood (reported in hours, includes time to travel to location, collect, and return home). In our models respondents are coded 0 if they do not use or gather that specific resource.[3] A handful of respondents also responded that it took them 0 minutes to collect said resource.

On average, time to collect fodder decreased over this time period by about 13 minutes (from 1.52 hours to 1.29 hours) and time to collect firewood decreased by over 2 hours (from 4.57 hours to 2.19 hours) (see Table 1). Figure 3 shows the distribution of time to collect fodder (Panel A) and firewood (Panel B). Looking at time to collect fodder it appears that much of the decrease in average time is due to the increase in respondents living in households that buy all the fodder they use or do not have any livestock (increasing percent coded as 0 minutes to collect fodder). For firewood we similarly see a big increase in those coded as spending 0 minutes collecting firewood but we also see increases in those reporting shorter times in general.

[3]We also estimated models using an alternative measure for time of resource extraction that calculated the average time to collect a resource for all households in a neighborhood that gathered that resource. This measure then provides an estimate of the natural resource availability of the neighborhood, accounting for typical needs in the neighborhood. We then used that neighborhood average as the value of time to collect fodder or firewood if that specific respondent lived in a household that did not gather that resource. Results for fodder are substantively identical to those presented here but the alternative measure of time to collect firewood was not statistically significant once we included any additional variables in the models.

Of course, the amount of time households spend on these tasks depends on the environmental conditions, the amount of the resource gathered vs purchased, and, for fodder, the number of livestock being supported. And so, some of the above decreases are because households do not need that resource anymore (i.e. they have no more livestock or no longer use firewood) and some because they start to purchase all of their needs. When we look only at those who gathered the resource in that year the mean drops from 1.84 hours to 1.69 hours from baseline to follow-up for fodder and from 5.69 to 3.31 for firewood between these two data collection points. There is also a substantial increase in the percent of respondents living in households that spend 30 min or less collecting each resource. These descriptive statistics reveal that even though there has been tremendous change in land use over this period which has diminished and removed some natural resources (Axinn and Ghimire 2011; Ghimire and Axinn 2010), in general households have decreased the time spent collecting fodder and firewood.

In Table 1 we show the distribution of the use-gather-purchase balance of resource use over time and by resource. 16% of respondents lived in households that did not have any livestock at baseline and 20% did so at follow-up. Fewer than 2% of respondents lived in households that bought all their fodder needs at baseline and 3% did so at follow-up. Over both time periods the largest percent lived in households that gathered all their fodder needs (39% and 38% respectively). For firewood, over 90% of households used firewood, but 14% of households bought all their firewood at baseline and 27% did so at follow-up. Again, the largest proportion of respondents lived in households that gathered all their firewood needs, 47% at baseline and 43% at follow-up.

To capture these varied patterns of resource use we examine several different measures. First, we have simple dichotomous measures denoting whether the respondent lives in a household that has any livestock and therefore would require fodder and a separate measure for whether the household uses firewood. Second, we created two categorical measures, one for fodder and one for firewood, denoting whether the respondent lives in a household that doesn't use that resource, uses that resource but buys it all, buys more than half of their resource needs, buys half of their needs, buys less than half, and buys none of the fodder or firewood they use. Categories were determined by the response options in the data collection instrument. These measures are entered into the models as separate dummy variables with not using the resource as the reference category. In models including time to collect fodder we also include a control for the number of livestock (cattle, buffalo, sheep, goats, and pigs) owned.[4], [5]

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[4]A few households reported extremely large numbers of some of these animals (e.g. 23 female buffaloes and 24 sheep or goats). We top coded this variable at 15 as 98% of respondents reported 0–15 livestock total.

[5]Of course, individuals and households elect where to gather their resources, and they likely are incorporating the quality of natural resources and their fertility desires simultaneously as they make that choice. Additionally, previous research in this setting has found that flora quality is itself related to fertility behaviors (Brauner-Otto 2014). Therefore, we also explore measures of the quality of the natural resources. Data come from flora plot surveys conducted in 1996 and 2006 from 265 flora plots selected from a variety of types of areas, located on the perimeter of the study site, and arranged at 250-meter intervals along equally spaced (1km) transects that extend 1,250 meters away from the perimeter (see Dangol and Maharjan 2012 for a more detailed discussion of the data collection.). Flora teams counted the number of different tree, shrub, and grass species in each plot yielding measures of species density (the number of plants in a flora plot), richness (total number of species present in a flora plot), and the balance between the two (plant diversity with the Shannon-Weiner Diversity Index, an index commonly used in ecological research and is considered a measure of biodiversity (c.f. Chiarucciet al. 1999; Patil and Taillie 1982)). We examined measures of the closest flora plot (as measured by distance as the-crow-flies) to reveal the most immediate environmental conditions facing individuals and households, but following

Other Dimensions of Change over Time

Environmental conditions are changing at the same time as access to other important neighborhood characteristics such as markets (where alternative fuel and fodder sources can be purchased), employers (where individuals could earn money used to purchase substitutes for gathered fuel or fodder), or schools (where individuals can obtain the human capital required to gain access to said employers). Additionally, these organizations and others, like health service providers, are places where individuals may be exposed to new ideas about family norms. As discussed above, one may be concerned that any observed relationship between changes in natural resources and desired family size is really due to changes in these other neighborhood characteristics. The CVFS allows us to control for these changes at the community or neighborhood level. We examine measures of the time to walk (in minutes) to the nearest school, health service provider, market, or employer.[6]

Household level characteristics such as wealth may also influence both use of natural resources and desired family size. We measure this via consumer durable ownership and control for the number of different types of consumer durables the household owns at each wave (includes: radios, TVs, bicycles, motorcycles, carts, tractors, irrigation and other farm implements, and gobar gas plants).

Additionally, we include controls for individual level characteristics: education (highest grade completed), marital status (ever married), and the total number of children born. All of these measures are measured separately at baseline and follow-up.

Analytic strategy

Our analysis strategy focuses on change over time in individual family size preference for men and women aged 15–33 at the 1996 baseline, so below age 45 by the 2008 follow-up interview. All individuals in our analysis are exposed to the risk of having a family size preference at both time points. Because of this, we keep all individuals in our models, and include measures of change in animal husbandry in our models of time spent collect fodder and measures of change in firewood use in our models of change in time to collect firewood. By this strategy, each individual remains in the analysis even if she/he stops keeping animals (due to migration, change in farming practices, or exit from farming) or stops using firewood (due to migration or changing in cooking and heating fuels). This strategy also allows us to include individuals who are not collecting fodder or firewood at baseline but are at the follow up interview. Furthermore, because we do not want to limit the sample based on our key independent variable (i.e. change in resource collection time) we also include those who had not yet started or who stopped gathering resources.[7]

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previous research on contextual effects in this setting we also investigate geoweighted measures that incorporate the entire study area weighting those plots closest to the respondent more heavily than those farther away (see Brauner-Otto 2014). However, none of the measures of flora diversity, density, and richness were significantly related to a change in desired family size. This may be because of the specific time span these measures refer to.

[6]Neighborhood measures come from Neighborhood History Calendars which cover up to 2003 and are lagged. Therefore time 1 measures describe the neighborhood in 1995 and time 2 describe 2003.

We also looked at measures of the number of years a respondent had a school, health service provider, market, or employer with a 5 minute walk. These were not statistically significant in any model.

[7]We estimated models excluding those who never gathered the resource and found results virtually identical to those we present here.

Our estimation strategy has two steps. First, we estimate the effect of the change in natural resources on the change in desired family size using fixed effects models that account for unobserved individual level heterogeneity. Fixed effect models exploit the within person variation (i.e. change) and in most situations yield estimates that are less biased and more valid than other panel data models (see Johnson 1995 for an accessible discussion of fixed-effect models). These models allow us to include controls of time varying, but not time-invariant, individual characteristics. The data set is set up with person-waves as the observations so all analyses capture change over time.

Fixed effect models are often considered the gold standard approach to use when panel data are available and clearly allow us to estimate models of change. They also generally yield unbiased estimates and account for unobserved individual characteristics that could be causing the observed relationship (Johnson 1995, 2005; Vaisey and Miles 2016). However, these models are computationally intensive as they rely on within-person change and they are less intuitive and more difficult to interpret.

Our second step was to estimate lagged dependent variable models—a simpler longitudinal approach. These models use desired family size at follow-up as the dependent variable, measures of the change in time to collect resources as the key independent variable, and control for baseline characteristics including baseline time to collect resource and baseline desired family size. These lagged variable models are generally fairly intuitive to interpret and tend to be highly efficient estimators (Johnson 2005). They reveal information on how time to collect resources and the change in that time is related to the *level* of desired family size. Note, in estimating these models we include additional baseline or time-invariant controls for respondent’s contraceptive use, parental education, household wealth (electricity, toilet facilities, and land ownership), religio-ethnic group, and birth cohort that computationally cannot be included in fixed effect models because they are either time-invariant by definition (e.g. religio-ethnic group, birth cohort) or in practice (e.g. parental education).

For both steps we first estimate zero order models which include only the time to collect the natural resource (fodder or firewood). We then add in the appropriate controls and finally add in our measures of the use-gather-purchase balance of resource use.[8] Because of the contrasting theories in the literature we use two-tailed tests of statistical significance. We conduct all analyses separately by gender given the gender inequalities in resource extraction activities, household decision making, and childrearing behavior discussed above.

Because individuals are also clustered within households and neighborhoods we estimated additional models with robust standard errors at the household and neighborhood levels. The results are substantively the same as those presented below. Because research using these data have consistently found that the neighborhood and household clustering accounts for very little of the individual variance (with Intraclass Correlation Coefficients (ICC)—the

[8]We also explored the role of migration but did not find any significant effects for whether a woman had moved from her baseline neighborhood. Other migration related dynamics such as the labor migration of other household members may be a part of the overall household functioning, and future research should examine the interaction between household migration patterns, resource use, and fertility preferences and behaviors.

measure commonly used to assess the extent of variance in the outcome due to the higher-level clustering— typically less than 0.10) we present the simpler models here.

Results

We first present the results from the fixed effect models. Table 2 shows the results of models with the change in time to collect fodder predicting women's change in desired family size. Model 1 presents those from the zero-order models and we see that, accounting only for unobserved individual level characteristics (i.e. the individual level fixed effects), women in households that increased the amount of time spent collecting fodder also increased their desired family size. These results confirm those found in cross-sectional research that relied on a retrospective measure of the respondent's perception on whether the time to collect fodder had increased from three years prior (Biddlecom et al. 2005). Model 2 shows the results when we add in the time-varying measure of owning livestock and the controls and we see that the effect estimate gets slightly larger (although it is unlikely to be statistically different from that seen in Model 1) and is more precisely estimated. Specifically, we see that a 1 hour increase in time to collect fodder corresponds with a 0.09 unit increase in the Coombs Scale. In comparison, women who obtained an additional grade of education between the two waves reported a 0.16 unit *decrease* in their desired family size as measured by the Coombs Scale.

Importantly, this result is independent of whether the respondent's household gathers fodder. In other analyses we examined our categorical measure of the use-gather-purchase balance of fodder use. Respondents in households that gather any fodder had significantly less change in desired family sizes than those who did not use fodder, but there were no significant differences across categories of the gather-purchase balance. Furthermore, including this measure does not change the effect of time to collect fodder on desired family size (in fact, the standard error decreases when the categorical measure is included). This demonstrates that households increased their desired family size when they spent more time collecting fodder, independent of whether they purchase additional fodder. Because of small cell sizes for some changes in the use-gather-purchase balance variable we do not present those models here.

By demonstrating a strong positive relationship between natural resource extraction and desired family size these results support population-environment models emphasizing household labor contributions. Women are often tasked with gathering fodder in this setting and fodder is an inelastic good – households with livestock must feed their animals and there are few, if any, readily obtainable substitutes in this setting. Under this circumstance, models reveal a positive association between living in a household that must devote more time to gathering this resource and women wanting more children. A likely reason is that these additional children can help alleviate the other household tasks women would otherwise be required to do (Cain 1977). It is a finding consistent with the labor value of children in this setting for this specific task. The increased demand for labor associated with collection of fodder from more distant locations affects everyone in the household, taking time away from other household tasks. It is also consistent with theories of the economic motivations for childbearing, that women of childbearing ages in these households identify having additional children as a potential contribution to the welfare of all in the household.

Table 3 shows the results for the models of the relationship between change in time to collect firewood and change in desired family size for women. The analysis presented in this table is an important change from the previous one to an entirely different natural resource gathered from the local environment for entirely different reasons. Firewood is gathered for heating and cooking, independent of ownership of livestock. Though still a forest product, wood to fuel fires is usually taken from different specific locations than leafy fodder to feed animals. It is a similarly, if not more, time consuming task, but a use of household labor for a different purpose.

In spite of these substantial differences, again we see positive effects such that women in households that increased the amount of time they spent collecting firewood increased their desired family size. Specifically, a 1 hour increase in time to collect firewood corresponds to a 0.03 unit increase in the Coombs Scale. This effect estimate is smaller than that seen for fodder, but because there is greater variation in and length of collection times for firewood this is not surprising.

In Model 2 we again incorporate our measure of whether the household uses firewood at all and the other time-varying controls. Here we see that the effect of time spent collecting firewood remains the same. Once we account for households that stop using firewood altogether we still see that women in households who spent more time collecting the resource increased their desired family size. Most households (over 90%) use firewood to some degree but there has been a steady shift towards purchasing firewood as opposed to gathering it. In other analyses we see that once we account for whether households gather firewood (as opposed to simply whether they use firewood) a change in the time to collect firewood is not statistically significant. However, the effect estimate is the same as that seen in Table 3 and since fixed effect estimates are data intensive (and, as with fodder collection, cell sizes become small when controlling for the use-gather-purchase balance) we do not place much weight on the lack of significance.

Natural resource collection time is closely connected to other community characteristics. If the surrounding areas are covered with built infrastructure (e.g. schools or markets) then, clearly, the time to collect resources will be longer. We are able to capitalize on the unique CVFS data on neighborhood organizations to examine this relationship directly (not shown in tables). However, none of the measures of changes in the built environment/neighborhood infrastructure were significantly related to a change in desired family size (see below for discussion on the relationship between *levels* of neighborhood development and desired family size). However, the null finding here may be because the amount of land use conversion occurring over the analysis period is actually quite small; the changing time to gather resources is because of changes happening outside the immediate neighborhood.

We also used CVFS measures of men's childbearing preferences (same Coombs scale) to assess the association of those preferences with time to collect fodder and firewood. We found no statistically significant effects for time to gather resources on men's desired family size (not shown in tables). Prior research on Nepal demonstrates men's engagement in non-family activities (e.g. school, work, travel) has a much stronger influence on couple level childbearing decisions than women's engagement in non-family activities (Axinn 1992). Work activities of men and women are both relevant to fertility change in Nepal, but the gendered nature of work in this setting (Agarwal 1994; Bennet 1983), likely produces important gender differences in which work activities are most relevant to fertility change. Our findings are then consistent with observed gender differences in the level of engagement in fodder and firewood collection (much higher for women than men in Nepal). These findings are in contrast to previous, cross-sectional work which found that men in households that reported a longer time to collect fodder had larger desired family sizes (Biddlecom et al. 2005).

Finally, in part to provide more intuitive results, we also estimated lagged dependent variable models predicting desired family size at follow-up (see Appendix Table A1). Our findings from these models are entirely consistent with the findings from the fixed effect models reported above. In the lagged models we find evidence that women in households that spent more time collecting fodder at baseline and had a bigger increase in the time spent doing so between waves had higher desired family sizes at follow-up (Model 1, Appendix Table A1). This effect size is similar in magnitude to that of desired family size at baseline (0.13 for change in time to collect fodder vs 0.12 for baseline Coombs Scale value). We also explored a 5 category categorical measure of time to collect fodder based on the distribution of the change in time and generally found significant differences across all categories (Model 2).[9] We also found similar relationships for women regarding the time spent collecting firewood (Models 3 and 4). These findings hold even when we include controls for the use-gather-purchase balance of resource use, type of land where fodder gathered, and other household and individual characteristics.

Additionally, we found that neighborhood resources were related to women's desired family size at follow-up, but that these effects are independent of time to collect fodder or firewood (see Appendix Table A2). Specifically, women living in neighborhoods that experienced growth in markets and schools (i.e. the distance to the closest market or school decreased between baseline and follow-up) had lower desired family sizes. This finding is in line with broad sociological theories linking social change and fertility.

Before turning to broader conclusions based on our findings we note that there are still remaining questions regarding the relationship between the environment and fertility. Although we found this pro-natalist effect of diminishing natural resource availability on desired family size it is unclear how this process will play out across levels of resource availability and land ownership. Like many environmental effects there may be a threshold effect after which the marginal return to child labor does not outweigh the costs. Or, as societies begin to rely less on public lands and more on market exchanges the natural

[9]To create these measures we first calculated the change in time to collect fodder and firewood. We then broke these distributions up into five roughly equal groups (quintiles) and created separate dummy variables for each category. Respondents were then coded 1 for the range that included the change in resource collection time they experienced. For example, if a women lived in a household that reported that they spent 1 hour collecting firewood at baseline and 45 minutes collecting firewood at follow-up she would be coded as 1 for "Decrease by 2 hours to 5 min (firewood)" and 0 for all the other dummy variables.

resource-fertility relationship may weaken and be dwarfed by income boosting effects of non-family organizations. And, although we focus on measures of access to fodder and firewood, many other dimensions of environmental quality also deserve investigation as it is quite possible that changes in other dimensions of the environment produce much different consequences for family size preferences. Likewise, processes of exit from animal husbandry and exit from firewood use for cooking and heating also deserve greater empirical attention. Comprehensive modeling of these processes was beyond the scope of the present paper (focused on change over time in family size preference), but each of these processes constitutes important potential responses to changes in access to resources. Additionally, it remains to be seen whether the decrease in desired family size does in fact result in lowered fertility and smaller families. All of these are areas ripe for future research.

Conclusion

Desired family size is a key component in the link between population and the environment. The neo-Malthusian perspective on this relationship holds that the two processes are positively related such that a decrease in natural resources would lead to a decrease in childbearing desires. Other perspectives argue that we may see a decrease in natural resources lead to an increase in childbearing desires. This is clearly described in the “vicious circle” argument in which the reliance on women and children for labor related to natural resource extraction influences environmental conditions such that a decrease in environmental quality leads to an increase in desired family size.

The juxtaposition of these two theoretical perspectives is more complex than it appears. Theoretically, the contrast may be problematic because both mechanisms may be operating in any given setting. The specific social, cultural, and institutional contexts may then condition which mechanism dominates (Kertzer 1995; McNicoll 1980). Empirically, properly identifying evidence of these separate perspectives requires accounting for changes in social organization that either shape both natural resources and fertility, or may at least condition the consequences of resource change for fertility preference. Also, the reciprocal nature of the population-environment relationship necessitates longitudinal data in order to properly identify the causal direction between the two factors.

In this paper we revisit this important environment-fertility relationship taking advantage of a unique longitudinal study. We use multi-level panel data and advanced analytic tools to examine the relationship between environmental change and fertility preferences. Some key results are consistent with prior cross-sectional studies of this population. However, the longitudinal measures allow fully dynamic models of change which also yield contrasting conclusions. The models include the dynamics in the local community institutional context, exits from farming, termination of animal husbandry, and transition to alternative fuel sources, all important for their potential consequences for demand for children.

We find support for the vicious circle perspective, beyond what previous cross-sectional research found, particularly as it applies to women. Women whose households experienced an increase in the time spent collecting fodder for animals or firewood increased their desired family size. These effects were independent of the household’s need for the resource (e.g. the number of animals owned) and the balance between gathering versus purchasing the resource. As local natural resources become scarcer and the associated labor demand increases, women in their childbearing years want to have more children – a choice we know will ultimately increase demand for local natural resources making them even more scarce (Axinn and Ghimire 2011). Likely reflecting the gendered divisions of resource gathering, household, and childrearing labor in Nepal, we do not find evidence that men's preferences are similar influenced by changing environmental factors.

The size of the effect estimates we found were small, but reasonable in comparison to other associations. Theoretically we would expect the effect of the number of children a woman has on her desired family size to be bigger than the amount of time an entire household devotes to one task. Similarly, it is reasonable to think that the effect of an extra year of schooling is two or three times that of household resource extraction. The full costs of these household activities are not born by one woman alone.

Of course the results we present here are setting specific. We know that fertility desires and behaviors are complex and influenced by a range of simultaneous factors (Johnson-Hanks et al. 2011). It is likely that adjusting family size desires is one of many response options families and households have and use when their resources become more limited (Bilsborrow and Okoth-Ogendo 1992; Davis 1963). Because of the tremendous changes in education and market activity family size has been declining in Nepal and may continue to do so. These changes also mean that households may be better able to use markets to substitute for gathering natural resources—perhaps buying alternative fuels or purchasing meat instead of raising it themselves. In fact, we see some evidence of this with respect to fuel sources. Yet we are not seeing these forces prevent an association between local natural resources and childbearing preferences in those households currently living in rural Nepal. Rather, families continue to rely heavily on gathering their own resources and when those efforts become more onerous, our results imply that fertility will increase. This will continue to weaken the environmental conditions households face and place further upward pressure on fertility.

Our results are evidence that even in a context of large scale macro-level influences creating widespread fertility limitation and pushing population-level fertility rates down (Axinn and Barber 2001; Axinn and Yabiku 2001), heterogeneity within the population continues to push toward higher than average fertility among those most engaged in use of local resources. Even if the social changes that put downward pressures on fertility continue to expand, there will likely continue to be households for which this vicious circle operates, and the environmental strain those households cause will influence other households as well. The consequences of diminishing environmental quality extend far beyond the households that are most intimately connected to it. This important result has broader implications for other settings characterized by a wide range of social and economic circumstances. It means that within populations over all characterized by low fertility and low use of local natural resources, it is still possible for some households using local natural resources to experience upward pressure on fertility from declining availability of those resources.

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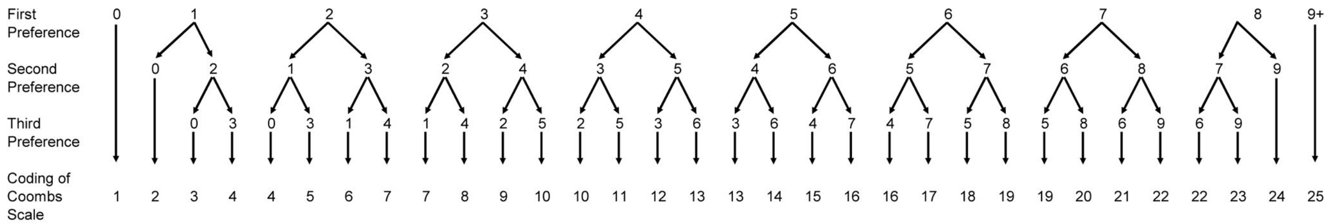

Figure 1.

Response alternatives and coding scheme for Coombs scale family size preference measure

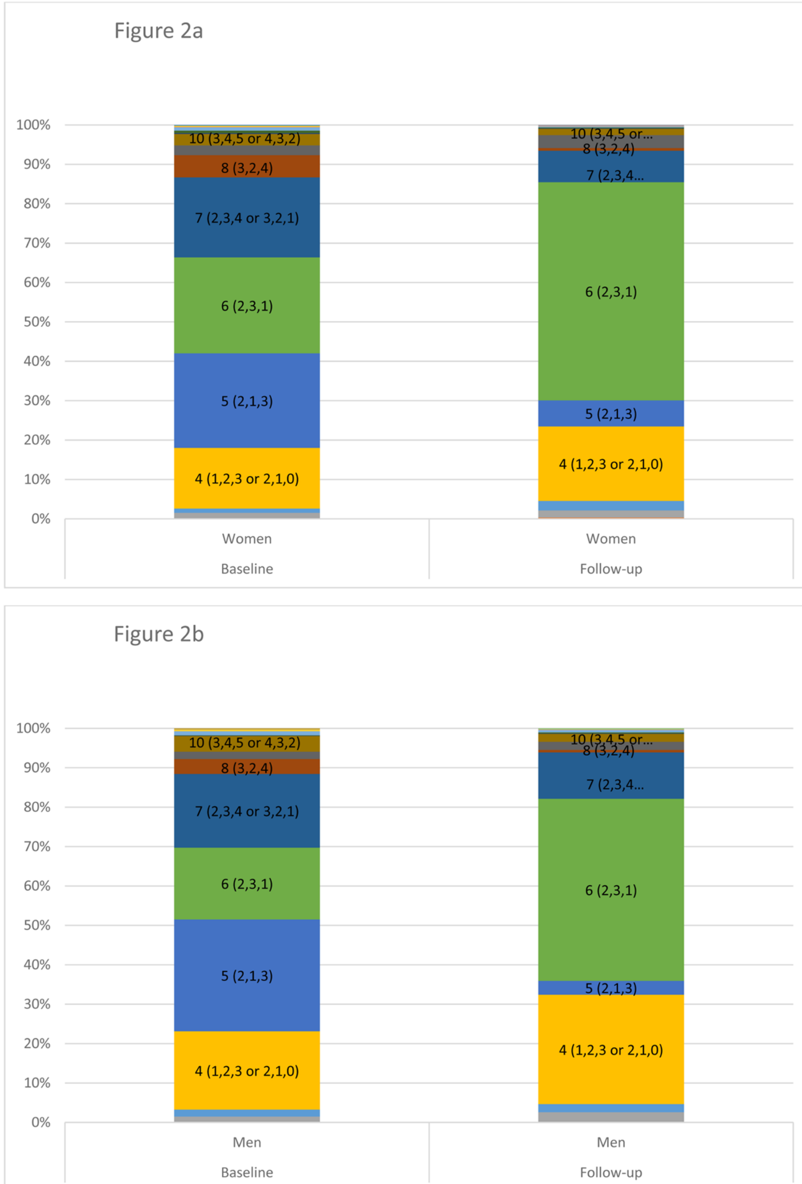

Figure 2.

Figure 2a. Distribution of Coombs Scale (desired family size) responses for women at baseline and follow-up. Value with number of children preference in parentheses.

Figure 2b. Distribution of Coombs Scale (desired family size) responses for men at baseline and follow-up. Value with number of children preference in parentheses.

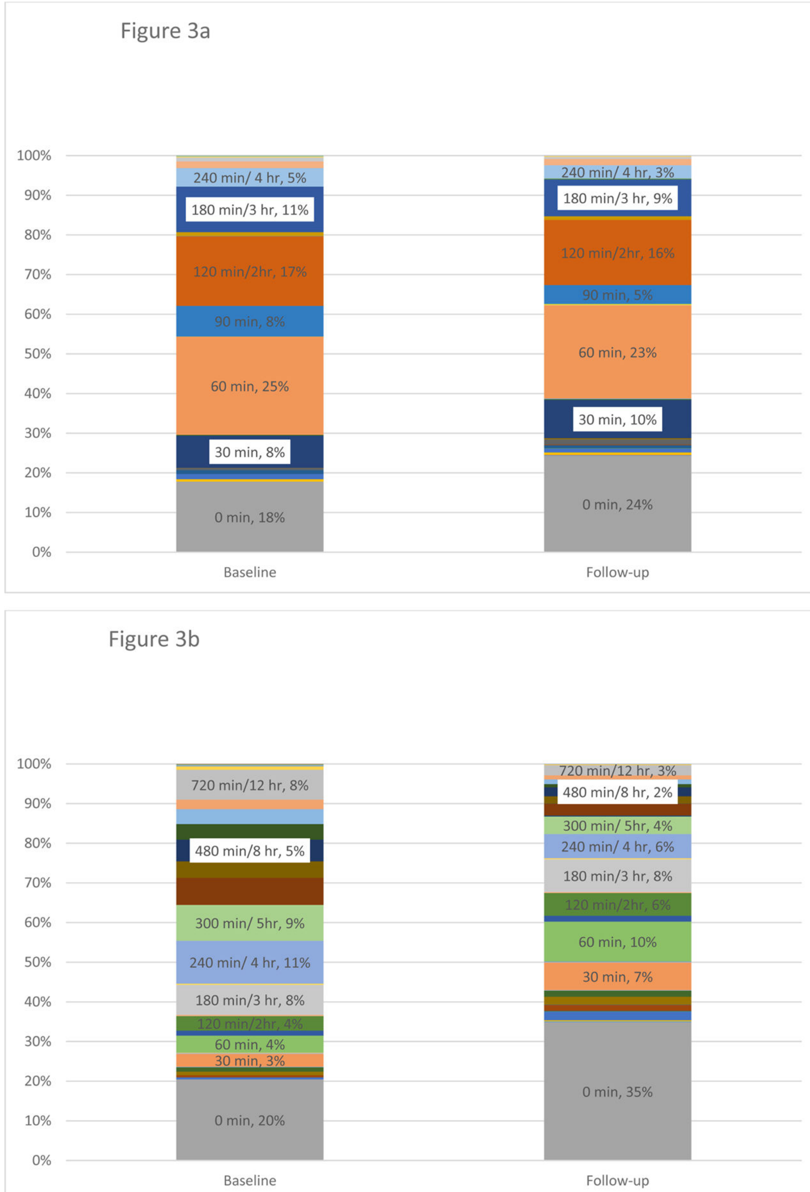

Figure 3.

Figure 3a. Time in minutes to collect fodder at baseline and follow-up (includes time to travel, gather and return home). Zero minutes includes men and women in households who buy all the fodder they use or do not have any livestock.

Figure 3b. Time in minutes to collect firewood at baseline and follow-up (includes time to travel, gather and return home). Zero minutes includes men and women in households who buy all the firewood they use or do not use any.

Table 1

Descriptive statistics. By wave (Baseline=1996, Follow-up=2008 for individual measures and 2006 for household/agricultural measures). N=2276 individuals (1254 women and 1022 men) from Chitwan Valley, Nepal.

	Baseline				Follow-up			
Variable description	**MIN**	**MAX**	**MEAN**	**STD**	**MIN**	**MAX**	**MEAN**	**STD**
Coombs scale value	1	25	5.96	2.02	1	25	5.71	1.84
Natural resource collection variables								
Hours to collect fodder	0	10	1.52	1.36	0	8	1.29	1.27
Intensity of fodder collection								
Gathers no fodder/has no livestock			15.51				20.43	
Gathers no fodder/buys all			1.80				3.03	
Gathers less than half of fodder			9.23				6.81	
Gathers half of fodder			22.45				19.82	
Gathers more than half of fodder			11.69				11.56	
Gathers all fodder			39.32				38.36	
Hours to collect firewood	0	17	4.57	3.97	0	14	2.19	3.06
Intensity of firewood collection								
Gathers no firewood/does not use firewood			5.89				7.07	
Gathers no firewood/buys all			13.75				26.85	
Gathers less than half of firewood			6.59				3.21	
Gathers half of firewood			18.54				14.67	
Gathers more than half of firewood			7.73				4.88	
Gathers all firewood			47.50				43.32	
Number of livestock household owns (bulls, cows, he buffaloes, she buffaloes, goats, pigs)	0	15	4.54	3.64	0	15	3.80	3.31
Flora plot measures								
Closest flora plot								
Density (number of plants)	3.86	1401.67	496.61	252.44	12.74	1463.33	430.77	318.30
Richness (number of species)	1	24	12.64	5.59	1	32	15.96	6.67
Shannon-Weiner Diversity Index	0	2.424	1.46	0.69	0	2.777	1.55	0.78
Geoweighted averages of all flora plots								
Density (number of plants)	1.83	409.67	14.60	37.56	1.30	272.84	10.10	25.90

	Baseline				Follow-up			
Variable description	MIN	MAX	MEAN	STD	MIN	MAX	MEAN	STD
Richness (number of species)	0.06	14.46	0.46	1.28	0.06	18.47	0.59	1.66
Shannon-Weiner Diversity Index	0.01	1.62	0.05	0.14	0.01	1.82	0.06	0.16
Controls								
Community characteristics								
Distance (min by foot) to nearest market	0	120	12.51	16.60	0	4	0.14	0.44
Distance (min by foot) to nearest school	0	30	9.21	6.64	0	25	6.95	6.53
Distance (min by foot) to nearest health post	0	90	20.65	17.88	0	30	8.47	5.93
Distance (min by foot) to nearest employer	0	180	21.00	20.82	0	30	5.70	6.31
Number of consumer durables hh owns	0	8	1.82	1.40	0	8	2.87	1.46
Household owns any land	0	1	0.84		0	1	0.76	
Education (highest grade respondent completed)	0	16	5.71	4.11	0	16	6.31	4.63
Married	0	1	0.61		0	1	0.94	
Total number of children born	0	7	1.30	1.55	0	11	2.39	1.48

Table 2

Models of change in desired family size (Coombs Scale) from baseline to follow-up predicted by change in time to collect fodder (hours to travel, gather, and return home). Effect estimates with t-statistics in parentheses from regression models with individual level fixed effects. Women aged 15–33 in Chitwan, Nepal at baseline.

	1	2
Hours to collect fodder (hours to travel, gather, and return home)	0.07+ (1.82)	0.09* (2.09)
Has any livestock (i.e. uses fodder)		−0.29 (−1.70)
Controls[a]		
Number of types of consumer durables household owns		−0.10* (−2.47)
Highest grade respondent completed		−0.16** (−2.93)
Respondent ever married		0.39* (2.32)
Total number of children born		−0.06 (−1.12)
Person periods	2508	2508
Respondents	1254	1254
Overall R-squared	0.003	0.056

Effect estimates with t-statistics in parantheses. Models also include intercept.

+0.10

*0.05

**0.01

***0.001;

two-tailed tests

[a]Control measures are wave specific and should therefore be interpreted as change measures.

Table 3

Models of change in desired family size (Coombs Scale) from baseline to follow-up predicted by change in time to collect firewood (hours to travel, gather, and return home). Effect estimates with t-statistics in parentheses from regression models with individual level fixed effects. Women aged 15–33 in Chitwan, Nepal at baseline.

	1	2
Hours to collect firewood	0.03** (2.73)	0.03+ (1.82)
Household uses firewood		−0.26 (−1.23)
Controls[a]		
Number of types of consumer durables household owns		−0.09* (−2.12)
Highest grade respondent completed		−0.16** (−2.93)
Respondent ever married		0.41* (2.43)
Total number of children born		−0.05 (−0.82)
Person periods	2508	2508
Respondents	1254	1254
Overall R-squared	0.010	0.061

Effect estimates with t-statistics in parantheses. Models also include intercept.

+0.10

*0.05

**0.01

***0.001;

two-tailed tests

[a]Control measures are wave specific and should therefore be interpreted as change measures.

Table A1

Effect estimates from models of desired family size (Coombs Scale) at follow-up predicted by change in time to collect resources. Women aged 15–33 in Chitwan, Nepal at baseline.

	Fodder		Firewood	
	1	2	3	4
Hours to collect resource at baseline	0.10 * (2.12)	0.08 (1.62)	0.05 * (2.48)	0.06 ** (2.75)
Change in hours to collect resource from baseline to follow-up	0.13 ** (3.24)		0.04 * (2.21)	
Change in hours to collect fodder from baseline to follow-up				
Decrease by an hour or more(fodder)/Decrease more than 6 hours (firewood) (reference category)				
Decrease by less than an hour to 10 min (fodder)/Decrease by 6 hours to 2 hours and 15 min (firewood)		0.36 * (2.25)		0.13 (0.79)
No change (fodder)/Decrease by 2 hours to 5 min (firewood)		0.30 * (1.74)		0.60 ** (2.93)
Increase by less than 1 hour (fodder)/Increase by up to 25 min (firewood)		0.49 * (2.30)		0.42 * (1.86)
Increase by more than 1 hour (fodder)/Increase by 30 min or more (firewood)		0.50 ** (2.80)		0.47 * (2.23)
Baseline desired family size (Coombs Scale)	0.12 *** (4.49)	0.12 *** (4.44)	0.12 *** (4.55)	0.12 *** (4.51)
Gathers all fodder/firewood needs at baseline	−0.1 (−1.01)	−0.13 (−1.22)	0 (0.05)	−0.02 (−0.19)
Controls (refer to respondent at baseline)				
Number of livestock household owns	0 (−0.17)	0 (−0.14)		
Highest grade respondent completed	−0.01 (−0.69)	−0.01 (−0.83)	−0.01 (−0.88)	−0.02 (−0.95)
Married	0.15 (1.00)	0.14 (0.92)	0.12 (0.84)	0.14 (0.94)
Total number of children born	0.28 *** (5.53)	0.28 *** (5.62)	0.28 *** (5.71)	0.28 *** (5.73)
Number of consumer durables household owns	0.03 (0.65)	0.02 (0.57)	0.02 (0.57)	0.02 (0.56)
Religio-ethnicity (High caste Hindu, reference group)				
Low caste	−0.07 (−0.41)	−0.08 (−0.46)	−0.19 (−1.06)	−0.22 (−1.21)
Hill janajati	−0.14 (−0.91)	−0.13 (−0.84)	−0.17 (−1.16)	−0.20 (−1.34)
Newar	−0.07 (−0.34)	−0.06 (−0.31)	−0.13 (−0.67)	−0.15 (−0.75)
Terai janajati	0.18 (1.18)	0.18 (1.18)	0.04 (0.30)	0.04 (0.25)
Birth cohort (Age<20 at Wave 1, reference group)				
Age 20–24 in 1996	−0.10 (−0.71)	−0.10 (−0.70)	−0.10 (−0.67)	−0.10 (−0.69)
Age 25–29 in 1996	0.03 (0.14)	0 (−0.01)	0.01 (0.07)	0 (0.03)
Age 30–34 in 1996	0.05 (0.21)	0 (0.01)	0.02 (0.11)	0.02 (0.08)
Ever used contraception	−0.38 ** (−3.09)	−0.38 ** (−3.04)	−0.36 ** (−2.95)	−0.35 ** (−2.86)
Parents education	0.03 (0.32)	0.04 (0.38)	0.04 (0.37)	0.05 (0.49)
Has toilet	−0.08 (−0.66)	−0.08 (−0.71)	−0.05 (−0.44)	−0.04 (−0.35)
Has electricity	0.16 (1.40)	0.15 (1.34)	0.19 (1.66)	0.19 (1.63)
Owns any farm land	0.01 (0.09)	0 (0.03)	−0.03 (−0.19)	−0.03 (−0.22)
obs read	1254	1254	1254	1254
Respondents	1241	1241	1241	1241

	Fodder		Firewood	
	1	**2**	**3**	**4**
Adjusted R-square	0.13	0.11	0.11	0.12

Effect estimates with t-statistics in parantheses. Models also include intercept.

+0.10

*0.05

**0.01

***0.001;

two-tailed tests

Table A2

Effect estimates from models of desired family size (Coombs Scale) at follow-up and neighborhood change. Women aged 15–33 in Chitwan, Nepal at baseline.

	1	2	3	4
	Market	**School**	**Employer**	**Health Post**
Hours to collect fodder in 1996	0.11 * (2.13)	0.11 * (2.27)	0.12 * (2.37)	0.10 * (2.00)
Change in hours to collect fodder in 1996–2006 (continuous)	0.13 ** (3.27)	0.13 ** (3.25)	0.13 ** (3.28)	0.13 ** (3.21)
Community context				
Distance to neighborhood organization in 1996[a]	−0.01 (−1.47)	−0.02 * (−2.44)	−0.01 (−1.29)	0 (0.88)
Change distance to neighborhood organization 1996–2003	−0.02 * (−2.06)	−0.03 + (−1.91)	0 (−0.61)	0 (0.78)
Baseline desired family size (Coombs Scale)	0.12 *** (4.62)	0.12 *** (4.41)	0.12 *** (4.38)	0.12 *** (4.50)
Respondents	1241	1241	1241	1241
Adjusted R-square	0.12	0.12	0.12	0.12

Effect estimates with t-statistics in parantheses. Models also include all controls described in text and in Table A1 and an intercept term.

+ 0.10

* 0.05

** 0.01

*** 0.001;

two-tailed tests

[a] Distance to each neighborhood organization was collected using the Neighborhood History Calendar approach. Distances are measured in minutes walk from the neighborhood center to each specific building.