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Wild foods contribute to women's higher dietary diversity in India

Jennifer Zavaleta Cheek[1,2], Nathalie J. Lambrecht[3,4], Bowy den Braber[5], Nirali Akanchha[6], Dhanapal Govindarajulu[6], Andrew D. Jones[7], Ashwini Chhatre[6], Laura Vang Rasmussen[5]

Affiliations

1. South Dakota State University, Department of Natural Resources, 1175 Medary Ave. Brookings, SD 57006, USA
2. University of Michigan, School for Environment and Sustainability, 440 Church St., Ann Arbor, MI 48109, USA
3. Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt-Universität zu Berlin, Institute of Public Health, Charitéplatz 1, 10117 Berlin, Germany
4. Research Department 2, Potsdam Institute for Climate Impact Research (PIK), Member of the Leibniz Association, P.O. Box 60 12 03, 14412 Potsdam, Germany
5. University of Copenhagen, Department of Geosciences and Natural Resource Management, Øster Voldgade 10, 1350 Copenhagen K, Denmark
6. Indian School of Business, Gachibowli, Hyderabad, Telangana 50032
7. University of Michigan, Department of Nutritional Sciences, School of Public Health, 1415 Washington Heights, Ann Arbor, MI 48109, USA

Editor's summary:

Wild foods may contribute to food security through different pathways. Using a monthly-interval dataset from two rural districts in India, this study elucidates the impact of wild food consumption from forests and common lands on women's dietary diversity.

Abstract:

Wild foods, from forests and common lands, can contribute to food and nutrition security. Most previous studies have established correlations between wild food consumption and children's dietary diversity in Africa, but other groups and geographic contexts remain understudied. Here, a rigorous quasi-experimental method was combined with monthly-interval data to assess the contribution of wild foods to women's diets. We collected 24-hour diet recall data monthly, from November 2016 to November 2017, from 570 households in East India. We found that wild foods contributed positively to diets, especially in June and July (when consumption of wild foods was highest). Women who consumed wild foods had higher average dietary diversity scores (13% and 9% higher in June and July, respectively) and were more likely to consume nutrient-dense, dark green leafy vegetables than those who did not. Our results

underscore the importance of policies that increase knowledge of wild foods and protect people's rights to access forests and other common lands for improved nutrition.

Main:

Around three billion people do not have access to healthy diets globally [1]. Inadequate consumption of sufficiently diverse and nutritious food sources leads to micronutrient deficiencies and an increased risk of morbidity and mortality [2]. Among women, undernutrition is associated with poor maternal health and childbirth outcomes, reduced work capacity, and adverse intergenerational consequences such as stunting and poor cognitive development in children [3]. India, where this study was conducted, has the highest population of undernourished people globally (224 million in 2019-2021) [1] and almost one-third of young children are stunted. In addition, 89% of women in India are estimated to be micronutrient deficient [4]. India shares a quarter of the global hunger burden, so understanding dietary quality dynamics in India has the potential to improve global averages [5]. As climate change threatens to make the poorest even more vulnerable to food insecurity [6], understanding how people can improve their diets is of paramount importance.

Many of the world's poorest people depend on natural resource collection for subsistence [7,8] and an estimated 1.5 billion people (just under 20 percent of the global population) live within 5 km of a forest [9]. In India, around 88 million people live within 5 km of a forest. Additionally, India has over 71 million hectares of forests (or about 22 percent of its geographical area [10]). Taken together, the highest population of undernourished people globally, high prevalence of micronutrient deficiencies, and the size and dependence of forests justifies our focus on India.

A growing evidence base suggests that forests and common lands contribute to the dietary quality of people living in close proximity to these areas [11,12]. In this paper, we consider "wild foods" as any foods that are not cultivated or grown at home. Wild foods occur in complex landscape mosaics, including forests and other common lands like farmlands that are not actively cultivated [13]. Wild foods fall along a continuum, from wild species under various degrees and types of human management and intervention through to domestication [14]. Wild foods can supply many essential micronutrients and contribute to caloric intake, especially during the lean season [15,16] or at times of low agricultural production [17]. In India, many wild foods are culturally important and harvested traditionally, but this can be limited by whether or not people have legal access to collect foods and/or the traditional knowledge to know where to find them, their toxicity, and seasonal abundance [18].

Research that link diets and wild foods has focused mostly on the role of forests and much less has been about common lands [19,20]. Not only do forests have the potential to impact diets directly through the consumption of food, they can also impact diets indirectly through increased income from forest products or through regulating ecosystem services such as pollination which can increase agricultural yields [21]. Forests have even been described as 'the supermarket of the wild' [16]. Most of the research to date has found positive associations between forest-level variables like the proportion of forest cover [22,23], distance to forests [24], or spatial configuration of forests [25] and people's dietary quality. Most studies use metrics of diet quality such as dietary diversity scores or consumption of certain nutritious food groups. Ickowitz et al. [24] used Demographic Health Survey data from 21 African countries and found that children up to five years old who lived in areas with more trees had more diverse and nutritional diets. Similarly, Galway et al.[23] showed that deforestation was associated with lower dietary diversity and less consumption of legumes, fruits and vegetables among children aged 6-24 months in 15 African countries. Rasolofoson et al.[25] used matching techniques to compare the dietary diversity and consumption of vitamin A and iron-rich foods of children that lived within 3 kilometers of 40 percent tree cover and those that did not. They found that children exposed to forests had 25% higher dietary diversity compared with those that did not. Not only does the extent of forest or forest change affect dietary diversity, Rasmussen et al.[26] found that a higher number of forest patches was associated with greater fruit consumption in four countries in Africa. Most recently, Hall et al. [26] used a combination of regression and weighting analyses to generate quasi-experimental quantitative estimates of the impacts of deforestation on people's food intake in Tanzania. They found that deforestation caused a reduction in fruit and vegetable consumption of 14 grams per day, which represented a substantial proportion (11%) of average daily intake.

Most of the research linking wild foods to dietary quality has been observational and focused on forest foods and children's diets in Africa. Our paper makes a number of contributions to the literature on the impacts of wild food consumption and diet quality through its use of rigorous, quasi-experimental methods, inclusion of common lands in addition to forests, and focus on women in India. Our analysis advances the literature by using (1) repeated monthly surveys tracing where foods were collected, thereby allowing us to observe which foods were sourced from the wild as well as seasonal changes in wild food collection and (2) matching – a rigorous, quasi-experimental method – to isolate the causal relationship between women who consume wild foods and their diets, thereby moving beyond previous research which primarily assessed associations. Specifically, we use an original, monthly-interval dataset from two rural districts in Jharkhand and West Bengal, India (Figure 1) to characterize the impact of wild food consumption on dietary diversity. We conduct statistical matching and regression analyses to control for potential socioeconomic and geospatial drivers of dietary diversity and wild food consumption. Matching allows us to compare women who did and did not consume wild foods but were similar with respect to income, caste, crop diversity, forest distance, forest area and area of common lands within a 3 km buffer from the village center, household size and 'baseline' dietary diversity in December 2016, so that the impact of wild foods on dietary diversity is isolated. The aims of this paper are to (1) determine how wild foods contribute to dietary diversity and (2) illuminate seasonal variations in consumption of wild foods.

Results

Women primarily consumed wild foods between the months of April and July, with the highest consumption in June and July (Figure 2). This coincided with the lean season when crops are planted but have not yet been harvested. Not only did women who consumed wild foods have higher average dietary diversity, they were also more likely to have consumed dark green leafy vegetables compared to women who did not consume wild foods in June and July (Figure 3).

We found that in June and July, the average dietary diversity scores (DDS) were 13% ($p=0.025$) and 9% ($p=0.047$) higher, respectively, among women who consumed wild foods (Figure 3) as compared to those women who did not consume wild foods. This equates to 0.34 extra food groups in June and 0.30 in July.
The most commonly consumed wild foods were a) dark green leafy vegetables like chakwar (*Senna obtusifolia*), jute leaf (*Corchorus olitorius*), kohkari (*Acalypha indica*), and khapra (*Boerhavia diffusa*) and b) other vitamin A-rich fruits and vegetables such as hog plums (*Spondias mombin*), bottle gourd (*Lagenaria siceraria*), and bamboo shoots (*Bambusa vulgaris*). We collected data on all wild foods that were consumed during the year (Supplementary Table S), but we did not analyze other food groups (e.g., fish) separately given the low overall consumption of these foods from the wild. Over the year, dark green leafy vegetable consumption in the past 24 hours ranged from 10-76% among women who had consumed wild foods, with generally lower consumption from January to March and highest consumption in July. Among women who did not consume wild foods, dark green leafy vegetable consumption ranged from 21-41%, and was highest from January to June and lowest in July to August.

With matching analyses, we found that the odds of consuming dark green leafy vegetables in June were 5 times higher ($p<0.001$) in both the past 24 hours and in the past 7 days among women who ate wild foods compared to women who did not (Figure 3). In July, the odds were 16 times higher ($p<0.001$) in the past 24 hours and 10 times higher in the past 7 days ($p<0.001$). We found that wild food consumption in June and

July did not affect the odds of consuming other fruits and vegetables that are rich in vitamin A.

Moreover, our results show that the consumption of dark green leafy vegetables appeared to be key to increasing the dietary diversity of women who consumed wild foods, especially at very low general levels of DDS. However, the consumption of wild foods did not change the likelihood that women achieved Minimum Dietary Diversity (MDD), i.e., the consumption of at least five food groups in a 24-hour period. Forty percent of the women in our sample never met MDD. Women who had very low levels of DDS (2 out of 10 food groups) and did not eat wild foods consumed grains and cereals and other vegetables, whereas women who ate wild foods consumed dark green leafy vegetables, along with grains and cereals, and other vegetables. This suggests that the consumption of dark green leafy vegetables from the wild should not be seen as purely a supplementary food group added at relatively high levels of DDS. Rather, it appears key for women with poor dietary diversity in June and July.

Discussion:

Our results indicate that wild foods, collected from forests and common lands, contribute to women's diets, especially for those with low dietary diversity during the lean season. Consumption of wild foods increased dietary diversity by 0.34 food groups in June and 0.30 in July. At an average DDS score of 3.5 across the year, an increase by a third of a food group is a meaningful contribution to women's diets in this area of India. Overall, 40% of the women in our study never met the minimum dietary diversity over one year, pointing to a great need to address poor diets. Our findings suggest that consumption of wild foods is important to vulnerable women, particularly during June and July when crops are still in the field and the amount of harvested crops from the year before is low.

In our study, wild green leafy vegetables contributed to improving women's diets, especially at very low levels of dietary diversity. The contribution of wild-harvested, dark green leafy vegetables to diets is particularly important to women who consumed wild foods in June and July given that at other times of the year these women either did not consume dark green leafy vegetables at all (50-90% of women depending on the month) or sourced from markets (4-27% of women). The price of green leafy vegetables varies seasonally, in contrast to the prices of other fruits and staple foods [27]. In India, the cost of green leafy vegetables rises steadily from January to July, at which point they are 25% higher than in January [27]. Our findings suggest that wild food harvesting provides women with a source of this nutritionally-important food group at a time when it is unaffordable at market.

Even though dark green leafy vegetables contribute little to total energy intake [28], they have a disproportionately large role in providing micronutrients like vitamin A and iron that are commonly deficient in the diets of low-income communities. Consumption of dark green leafy vegetables has been associated with improved nutritional outcomes of people in Tanzania [13], Gabon [29], and Benin [30]. Green leafy vegetables may also confer other health benefits such as glycemic control, immunostimulation and antioxidant activity [31].

The positive impact of wild foods on the consumption of one additional food group, green leafy vegetables, was not observed for the food group "other vitamin A-rich fruits and vegetables." That is, the likelihood of consuming this food group was not higher for women who collected wild foods. We suspect that the effect of wildly collected vitamin A-rich foods was muted as women could access these foods from other sources such as markets at relatively affordable prices.

Wild foods, particularly green leafy vegetables, are also culturally important to Indigenous communities in India [32]. Indigenous cultures have long relied on forests and other natural areas for food and medicine, and displacement and restricted access of local communities from these areas for conservation purposes has enormous implications for local communities' nutrition and health [33]. Our findings further emphasize the importance of ensuring local communities can use forests and other natural resources for improved food security and nutrition. Wild food collection is a long-standing strategy that is already used by the poor, so it is more accessible than other top-down technological fixes like golden rice or other biofortified crops that would have to be purchased [15].

Our results may underestimate the influence of wild foods on dietary diversity since people may have been hesitant to admit that they collected wild food, especially when it was not legally sanctioned [34] and because we only included wild food consumption in the past 24 hours and not any time in the last month. The short recall period may have excluded people who only occasionally eat foods from the forest. Furthermore, we did not collect data on wild foods that were purchased in the market or eaten at communal events. Additionally, data on the quantity of food consumed by individuals was not assessed, and so we relied on dietary diversity scores and consumption of nutritious food groups (i.e., dark green leafy vegetables and vitamin A rich fruits and vegetables) as proxies for overall dietary quality. Yet, quantification of household energy and nutrient adequacy levels will be important next steps to more accurately assess the seasonal contribution of wild foods to micronutrient intake. Furthermore, assessment of individual nutritional status using anthropometry as well as diet-related health outcomes (e.g., anemia, metabolic syndrome) would be helpful for understanding associations of wild food consumption with health status and informing policy to support seasonal gaps in diet.

Despite the monthly repeated survey, this dataset was only for one year. Although our research examined dietary trends across multiple months, future research would benefit from following the same individuals and households over multiple years. Furthermore, data across different years allows for exploration of how changes in weather patterns and land use like forest loss contribute to seasonal dietary diversity and dependence on the forest.

Future research should also include more precise forest-level variables, including the types of forests (e.g., deciduous or dry shrubs) or the plant species that most contribute to diets, to make policy recommendations on what types of forests are highest priority to conserve and what species to replant. In addition to physical characteristics, it is also useful to understand the dynamics of how rights to access and harvest wild foods affect dietary diversity. Forest rights have a long legacy in India and have been codified across different government regimes and scales, so where and what people can harvest from the forest is highly variable [35]. Our study sites include tribal areas that have special privileges under the Panchayat Extension of Scheduled Act,1996 and the Forest Rights Act, 2006. However, there is complexity in the enforcement of forest rights [36]. Both of our study sites do not have clear rights and tenure although people have customarily used the forests. To better understand the landscape of forest rights in the context of diets, we described which combination of forest rights is most common in our study site (Supplementary Figure 1). Yet, we note that because there was no variation of access across households within our study villages, our matching analysis does not include these variables. Instead, we focused our analysis on whether or not people actually consumed wild foods, irrespective of their forest rights.

Our findings thus suggest that accessing forests and common lands to collect wild foods can fill a critical gap in the diets of Indian women to improve diet quality, particularly among those who have the lowest levels of dietary diversity. Policies and programs should support consumption of wild foods, including through increasing educational messages about the nutritional value of wild foods and increasing access to forests and common lands. Especially education about the nutrition benefits is important as the collection of wild foods is often stigmatized as a symbol of poverty. This paper makes an important contribution to the literature as our dataset captured the seasonal relationships between wild foods and diets in India, an important yet understudied country. India performs poorly on undernutrition indicators, exhibiting high rates of underweight (23%) and anemia (53%) among adult women [27,37]. Since India is home to nearly a quarter of the world's population, discovering opportunities to enhance dietary diversity has the potential to impact a large number of vulnerable people. This high-temporal resolution dataset also highlights seasonal differences and suggests that access to wild foods is most crucial in June and July. In summary, our study shows the importance of wild foods for improving dietary quality of the most vulnerable, while highlighting the importance of policies that protect people's rights to access forests and other common lands for food and other services.

Methods:

Study Site

Our study site included 570 households, covering 40 villages in two districts in rainfed regions of India: Palamu, Jharkhand and Bankura, West Bengal (Figure 1). These sites have monsoons in July through October [38] that shape seasonal food security, income diversity, and dependence on the forest and common lands [39]. The two study sites are also home to some of the region's most impoverished people, where many live in extreme poverty, which is less than US$1.90 dollar a day [37]. The sites are rural and have representation across caste-levels, including high populations of people from scheduled tribes who often face social and economic discrimination [40] and are dependent on the forest [41,42].

Like in other parts of South Asia, villages and the surrounding areas in our study sites include both private, cultivated land, and common lands. The forests in our study sites are mostly open scrub, tropical dry deciduous, and tropical moist deciduous [43] and patches range in size up to 228 hectares (Figure 1). Common lands, which are characterized by their noncultivated status, include woodlots, pastures, waste lands, and other multiple-use land. Common lands are a type of common pool resource that is collectively owned. From the pre-British period and even up to the mid-nineteenth century, a substantial portion of land was available for communal use, including for grazing and collecting forest products and even though communal access can take many forms, usufruct rights to common lands remain common [44] (Supplementary Figure 1). The common areas in our site were consistently 23 ha for all villages in Bankura and 13 ha for all villages in Palamu as recorded in the most recent Census of India in 2011. Common lands have free standing trees that are too sparse to qualify as forest and can also include bushes and water bodies. Like forests, it is mostly the poorest people who access common lands for their subsistence needs like collecting fodder and dung, grazing, and food and even for income generation, especially in the lean season [45,46]. Unlike forests, relatively little is known about how common lands contribute to diets and what we do know about how commons contribute to livelihoods is from the arid and semi-arid regions [46] and hills and forest fringe regions [47] in India, but not the sub-humid regions.

Household Survey Data Collection

Twenty-three local enumerators conducted paper-based household surveys each month from November 2016 to November 2017. Villages were randomly selected from within each district based on a complete village list from the District Panchayat. Households– defined as a group of family members that share a communal kitchen–were randomly selected from complete village rosters that were created from census data and in consultation with village headmen to ensure that all households were represented. Within each household, we randomly selected one adult woman. Each interview took from an hour to an hour and a half to complete. See Supplementary Table 2 for the survey pertaining to dietary data collection. Enumerators visited each household every month, with the goal of visiting approximately four weeks apart and on different days of the week. This effort was done so that enumerators did not over or underestimate diets given that weekly *haats*, or village markets, often fall on the same day per week and market access is known to influence people's dietary diversity[48]. All participants were asked for consent each month to voluntarily participate in this study. Human subjects data collection for this research was approved by the University of Michigan Institutional Review Board (protocol # HUM00103723).

Paper forms were entered into the English-language Qualtrics (Qualtrics, Provo, UT). Quality control happened at two-levels: in the field at monthly enumerator meetings where enumerators checked one another's forms and those with missing or suspicious information had to go back to the field to collect missing data with a research coordinator. Forms were also systematically checked to flag forms that were missing sections or had irregular answers that needed to be verified. Research coordinators then checked written forms for answers that were not entered correctly and also made efforts to contact households directly to verify responses.

Outcome variables

To evaluate diets, we conducted both qualitative 24-hour dietary recalls as well as 7-day food recalls. For the 24-hour diet assessment, participants were asked to list all food consumed from when they woke up in the morning to when they went to sleep the day before [49]. Participants were also asked where each food item was obtained from, including if it was harvested from forests or common lands, was self-grown, purchased in the market, obtained through income compensation, bartered for, or obtained through the public distribution system (Supplementary Table 2). The amounts of each food consumed were not assessed.

Open-ended answers were converted in OpenRefine [50] such that slang, misspelled words, or non-English words were standardized. Food items were dichotomized into 10 food groups based on the Food and Agricultural Organization (FAO) and Food and Nutrition Technical Assistance II Project guidelines [49]: 1) grains, white roots and tubers, and plantains, 2) pulses (beans, peas and lentils), 3) nuts and seeds, 4) dairy, 5) meat, poultry and fish, 6) eggs, 7) dark green leafy vegetables, 8) other vitamin A-rich fruits and vegetables, 9) other vegetables, and 10) other fruits.

Additionally, we asked people how many times in the last seven days they ate red, yellow fleshy fruits or vegetables; dark green leafy vegetables; dairy products; vegetarian protein, including pulses and nuts; and non-vegetarian protein. To guide them through this process we asked them to think about each food item they may have eaten in each group and then asked them about frequency they ate it and where the food came from, as was done in the 24-hour food recall survey.

We used both 24-hour recall and 7-day food frequency data to calculate a variety of outcome variables related to dietary diversity, an important component of diet quality. First, we calculated Women's Dietary Diversity Score (DDS) as the sum of ten food groups a woman consumed the preceding day, ranging from 0 to 10 [51]. Second, we calculated the Minimum Dietary Diversity (MDD), which is a dichotomous variable to assess whether women consumed at least five of the ten food groups. MDD is associated with micronutrient adequacy among women of reproductive age [52]. We also examined consumption of specific food groups which we hypothesized could be obtained from forests and common lands, including dark green leafy vegetables and vitamin A-rich fruits and vegetables. For more on summary statistics across dietary outcome variables for women who did and did not consume wild food see Supplementary Table 3.

Matched covariates

We selected matching covariates *a priori* based on those that would be associated with dietary diversity or the likelihood of consuming wild foods. As for wild foods, we included wild foods obtained via self-harvest from forests, water bodies, or other common lands. Households were matched on monthly income, caste, crop diversity, household size, 'baseline' dietary diversity in December 2016 (December was used instead of November as the sample size was larger), proximity to forests, and total amount of forest area and common lands with a 3 km buffer from village center (For more details on summary statistics see Supplementary Table 4). Caste was parsed into two categories: scheduled tribe and everyone else. Schedule tribes have lived in and near forests since time immemorial and their culture and way of life is intimately related to the forest, including collecting food from it [15,42]. Crop diversity was a measure of how many crops a household harvested on their own land during Kharif growing season. To calculate forest proximity we used remotely sensed satellite imagery Sentinel-1 from Google Earth Engine. We used QGIS to draw a 3 kilometer radius around the center of each village to determine if forest was proximate and identified forests that had at least 10 percent tree cover in a plot of 1 hectare size as defined by the Forest Survey of India data for 2019 [10].

Statistical Analysis

We performed a quasi-experimental impact evaluation to determine the causal link between wild food consumption and dietary diversity in June and July. We selected these months because that was when consumption of forest foods was the highest. To isolate the role that wild foods have on diet [53] for each month we first created a group of women who ate at least one wild food item and a control group of women who did not eat wild foods. Then we used genetic matching [54] to pair each woman who consumed wild foods to a member of the control group with similar characteristics based on the covariate values. Genetic matching uses an optimization algorithm to find the best matches and has shown to perform well under diverse circumstances [55]. We performed an exact match on caste and district. For the remaining covariates we achieved sufficient balance (SD<0.25, Stuart 2010, Supplementary Figure 2). We used the MatchIt package [53] in R (version 4.0.5) to perform the matching analyses. After matching we performed regression analyses to correct for any remaining imbalances in covariates. We conducted quasi-Poisson regression analysis to estimate the effect of wild food consumption on DDS. When modeling binary outcome variables (consumption of specific food groups and MDD) we used logit models and calculated odds ratios. Finally, we used the sandwich package in R to calculate heteroskedasticity-robust (type "HC1") standard errors [56].

Data Availability

The data that support the findings of this manuscript are available at: https://openprairie.sdstate.edu/nrm_datasets/6/.

Code Availability

The codes used for this analysis are available at: https://openprairie.sdstate.edu/nrm_datasets/6/.

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Corresponding author: Jennifer Zavaleta Cheek, Email: Jennifer.ZavaletaCheek@sdstate.edu

Contributions

JZC and AC facilitated data collection. JZC, NJL, LVR, ADJ, and AC developed the conceptual model for the paper. LVR and NJL did initial modeling and statistical analysis and matching analysis was completed by BdB. DG made maps. DG, NA, and AC provided cultural and historical context for the paper. All authors discussed the results and contributed to the final manuscript.

Ethics declaration – Competing interests

The authors declare no competing interests.

Figure captions

Figure 1. The selected villages and the forests that surround them in Bankura and Palamu District. This information as sourced from freely available data from Google Earth Engine.

Figure 2: Percentage of women in the sample that consumed wild foods each month from November 2016 to November 2017. N=570 households

Figure 3: Comparison of the average dietary diversity score, minimum dietary diversity, and consumption of dark green leafy vegetables and other vitamin-A rich fruits and vegetables of women who ate wild foods compared with a matched control of women who did not eat wild foods. For dietary diversity score (DDS), data are presented as risk ratios based on quasi-Poisson regression after matching. For Minimum Dietary Diversity (MDS) and consumption of dark green leafy vegetables and vitamin-A rich fruits and vegetables, data are presented as odds ratios based on logistic regression after matching. Error bars indicate 95% confidence intervals (n=127). Asterisks indicate postmatching regression results that are significantly different from zero: * $P < 0.05$; ***$P < 0.001$.

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Supplementary information

Supplementary Figure 1. Flower diagrams illustrating the bundles of forest use rights across various levels of use rights (1-14 use rights).

Supplementary Figure 2. Balance of covariates before and after genetic matching for June (A) and July (B), comparing women who consumed wild foods to women who did not.

Supplementary Table 1. Name of wild foods and number of households consuming those foods each month from November 2016 to November 2017 in Palamu, Jharkhand and Bankura, West Bengal in India.

Supplementary Table 2. Questions from the survey used to collect information on 24-hour food recall and where foods were sourced.

Supplementary Table 3. Unmatched diet indicators among women who did and did not consume wild foods in June and July 2017 in Palamu and Bankura, India.

Supplementary Table 4. Household characteristics of unmatched sample of women who consumed wild foods and those who did not consume wild foods in June and July 2017 in Palamu and Bankura, India.