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Dietary quality and tree cover in Africa☆

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ABSTRACT

The relationship between forests and human nutrition is not yet well understood. A better understanding of this relationship is vital at a time when the majority of new land for agriculture is being cleared from forests. We use Demographic Health Survey data on food consumption for children from 21 African countries and Global Land Cover Facility tree cover data to examine the relationship between tree cover and three key indicators of nutritional quality of children's diets: dietary diversity, fruit and vegetable consumption, and animal source food consumption. Our main findings can be summarized as follows: there is a statistically significant positive relationship between tree cover and dietary diversity; fruit and vegetable consumption increases with tree cover until a peak of 45% tree cover and then declines; and there is no relationship between animal source food consumption and tree cover. Overall our findings suggest that children in Africa who live in areas with more tree cover have more diverse and nutritious diets.

1. Introduction

The contribution of forests and tree-based agricultural systems to human nutrition remains poorly understood (Colfer et al., 2008; Vinceti et al., 2013). As more and more of the world's forests are cleared in large part with the aim of providing more food to a growing human population (Gibbs et al., 2010; Godfray et al., 2010; Lambin and Meyfroidt, 2011; Phalan et al., 2011; Pretty, 1998), the need to better understand the entire range of the contributions that forest make to human diets takes on increasing urgency. Several recent papers suggest that forests might have beneficial impacts on human nutrition (Arnold et al., 2011; Colfer et al., 2008; Vinceti et al., 2013), but there is as yet scant empirical evidence to support these claims. This paper investigates whether there is a statistical association between tree cover and the nutritional quality of children's diets using data from 21 African countries.

It is increasingly recognized that nutrition is a vital dimension of food security (FAO, 1998; Pinstrup-Andersen, 2009). In 2012, the Food and Agricultural Organization estimated that 868 million people in the world did not consume sufficient food energy (calories), but that micronutrient deficiency affected over 2 billion people (FAO et al., 2012). Micronutrient deficiency is often called the "*hidden hunger*" because it can occur even when diets include an adequate amount of energy (calories). Iron, vitamin A, iodine and zinc are the micronutrients most commonly deficient in diets around the world (WHO, 2000; UN, 2004).

We create a new dataset by combining dietary intake data for over 93,000 children from 21 Demographic Health Surveys from across the African continent with GIS data from the Global Land Cover Facility on tree cover (as well as data from other datasets). We use this dataset to empirically examine whether there is a relationship between tree cover and three key indicators of dietary quality which are known to be associated with micronutrient intake: dietary diversity, consumption of fruits and vegetables, and consumption of animal source foods (Arimond et al., 2010; Neumann et al., 2003; Ruel et al., 2005).

How might tree cover affect the nutritional quality of children's diets? There are at least three possible pathways. First, people living near forests could have greater access to nutritious wild foods than people living in other ecosystems; such foods might include wild fruits, leafy greens, grubs, snails, and bush meat. Second, households that plant or harvest agro-forests on their land may benefit from increased access to fruits and nuts from trees. Third, it is possible that the agricultural techniques used in more forested areas, particularly shifting cultivation, might be more conducive to diversified and nutritious diets since such practices often involve complex mosaics of multiple crops. For any of these possible pathways to result in differences in diets and nutrition, however, there would also have to be some accompanying market imperfection that prevents people in all places from having the same market-mediated access to nutritious foods.

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There are two ways that a household can access nutritious food: either by direct production (or collection) or by purchase. If markets operate perfectly, then there should be little difference in consumption related to vegetation cover unless the vegetation cover affects productivity (and thus income) because people would be able to purchase nutritious food no matter their location. If markets are imperfect, however, then there could be differences in consumption associated with tree cover if any of the three pathways described above hold.

If markets function well and we assume that nutritious foods are 'normal' goods (a normal good is a good whose consumption increases as income increases), then we would expect that people with lower income would be less likely to consume more nutritious foods. There is considerable evidence that people living in forested areas tend to have lower incomes than those in other areas (Fisher and Christopher, 2007; Sunderlin et al., 2008). Therefore, we would expect people living in forested areas to have poorer quality diets, *ceteris paribus*, since they tend to have lower incomes. If markets for nutritious foods are imperfect, however, and people living in more forested areas have better access to nutritious foods unmediated by markets, then it is possible that they could have more diverse and nutritious diets through one, or more, of the three pathways described above.

There is reason to believe that markets for many nutritious foods in the rural areas of developing countries are likely to be imperfect (Ruel et al., 2005). As with many agricultural goods produced in rural areas of developing countries, imperfections in labor, land, insurance, and credit markets all have impacts on the agricultural output produced and sold by small farmers (Key et al., 2000; Singh et al., 1986). In addition to these difficulties, however, fresh meat, fruits, and vegetables are highly perishable, resulting in high transaction costs in getting them to market, thus creating a gap between the buying and selling price of these nutritious foods (Ruel et al., 2005). The larger the gap, the less likely the household is to participate in the market. Many households may therefore only produce/collect such goods for their own consumption. If this is the case, then we would expect to see greater consumption of certain types of nutritious foods in areas where they are more available.

2. Data

Demographic Health Surveys are nationally representative household surveys developed by the United States' Agency for International Development for the collection of data on health and fertility in many developing countries. These surveys use model questionnaires and standardized data formats to ensure that data are comparable across countries. We use the data from 21 country surveys that were completed during the period 2003–2011. Fig. 1 shows the location of the communities included in the analysis.

As a component of these surveys, female respondents are asked detailed questions about the diets of their children born in the last five years. The Demographic Health Survey data (and thus this paper) focus on children under five years because they are the most nutritionally vulnerable members of a community. We focus on children between the ages of 12 and 60 months because before 12 months children are still heavily dependent on breast milk or formula and thus have limited diets. While many African children continue to breastfeed after 12 months, complementary foods take on an increasing importance in their diets (UN, 2004). The most recent rounds of Demographic Health Surveys include questions on whether a child ate foods from various food groups in the previous twenty-four hours. From this information we created two types of indicators of dietary quality: dietary diversity and consumption of nutritionally important foods (fruits and vegetables; and animal source foods).

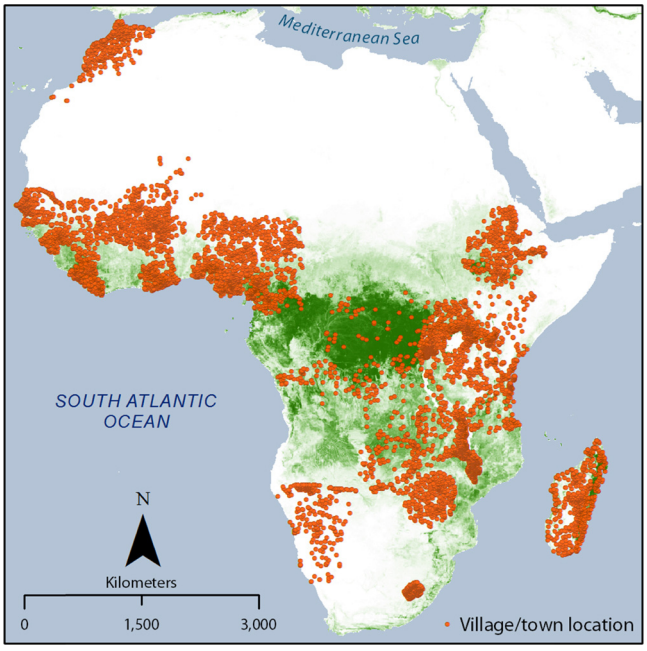

Fig. 1. Locations of communities from the Demographic Health Surveys.

2.1. Dietary diversity

A diverse diet is more likely to contain adequate amounts of all essential nutrients and less likely to contain large amounts of any one potential toxin. Dietary diversity is increasingly accepted as an essential component of healthy diets and is associated with nutrient intake. Adequate nutrient intake has been shown to be closely associated with physical and cognitive growth of children as well as lower morbidity and mortality (Arimond and Ruel, 2004; Arimond et al., 2010; Black et al., 2003; Kant et al., 1993; Kennedy et al., 2007; Ruel, 2003).

We created a dietary diversity score by adding up the number of food groups represented in the child's diet of the previous twenty-four hour period. The Demographic Health Survey data collection follows recent efforts to standardize dietary diversity scores and data collection methodologies (FAO et al., 2012; Kennedy et al., 2011). Despite these efforts, there remain different opinions on the number and types of food groups that should be included in dietary diversity scores in part due to data availability (Ruel, 2003) and to differing local contexts (Kennedy et al., 2011).

The Food and Agricultural Organization (FAO) and the Food and Nutrition Technical Assistance Project (FANTA) guidelines for creating an individual dietary diversity score recommend using the following 14 food groups: cereals; vitamin A rich vegetables and tubers; white roots and tubers; green leafy vegetables; other vegetables; vitamin A rich fruits; other fruits; organ meat; flesh meat; eggs; fish; legumes, nuts and seeds; milk and milk products; oils and fats. We create a dietary diversity score based on these guidelines, but only include ten of the fourteen food groups. About half of the countries from the Demographic Health Surveys that we use do not disaggregate the animal source foods, so we combine 'flesh meat', 'organ meat', 'fish', and 'eggs' into one category: animal source foods. In addition, the Demographic Health Surveys combine 'other fruits' and 'other vegetables' into one group.

2.2. Intake of fruit, vegetables and animal source foods

Since the dietary diversity score gives each food group equal weight and all food groups are not equally important for nutrition (especially for intake of micronutrients which are most commonly