Health & Place 51 (2018) 78–88

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Deforestation and child diet diversity: A geospatial analysis of 15 Sub-Saharan African countries

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ARTICLE INFO

Keywords:
Deforestation
Diet diversity
Diet quality
Biodiversity
Sub-Saharan Africa

ABSTRACT

Deforestation worldwide could have important consequences for diet quality and human nutrition given the numerous ecosystem services that are provided by forests and biodiverse landscapes. Yet, empirical research assessing the links between deforestation and diets is lacking. In this study, we examined the association between deforestation and diet diversity among children using geolocated Demographic and Health Survey data for 33,777 children across 15 countries of sub-Saharan Africa coupled with remotely-sensed data on forest cover loss. Deforestation was negatively associated with diet diversity (regression coefficient (95% CI): – 0.47 (– 0.76, – 0.18)), as well as recent consumption of legumes and nuts, flesh foods, and fruits and vegetables among children aged 6 months to 24 months. Regionally, these trends were statistically significant only in the West Africa region. This hypothesis-generating research adds to the growing body of evidence that forests and forest-based ecosystems are associated with diet quality and nutrition and provides support for future studies that examine mechanisms linking forest loss and human nutrition.

1. Introduction

Forested landscapes and forest biodiversity provide a range of ecosystem services that benefit human populations including provisioning (e.g., food and timber), regulating (e.g., pollination), cultural (e.g., spiritual benefits), and supporting (e.g., nutrient cycling and soil formation) services (Colfer et al., 2006; Foley et al., 2005; Millennium Ecosystem Assessment, 2005; Whitmee et al., 2015). It is increasingly recognized that forests play an important role in supporting livelihoods and shaping human health and well-being, particularly in developing countries (Rasmussen et al., 2017; Reed et al., 2017).

Due to a range of interconnected drivers including agriculture expansion and intensification, resource extraction, and population growth, deforestation is occurring globally at an alarming rate (Geist and Lambin, 2001; Hosonuma et al., 2012). Between 2000 and 2012, approximately 2.3 million square kilometers of forest cover was lost worldwide due to human and natural causes (Hansen et al., 2013). Deforestation has occurred most extensively and rapidly in the tropics accounting for approximately 32% of global forest loss during this same period (Hansen et al., 2013; Lindquist et al., 2012). Despite successful reforestation initiatives in a handful of individual countries, projections indicate that forest cover will continue to decline across the tropics, including in sub-Saharan Africa (SSA) where the rate of deforestation is twice the world average (Austin et al., 2017; d'd'Annunzio et al., 2015; FAO, 2010; Gibson et al., 2011; United Nations Environment Programme, 2008). Deforestation, and the associated loss of biodiversity, may jeopardize the provision of critical ecosystem services that support livelihoods and human health in this region (Aerts and Honnay, 2011; Brown et al., 2014).

The emergence of high-resolution satellite-derived data on forest change and georeferenced health data provides a unique opportunity to examine the links between deforestation and health-related outcomes. While causality has generally not been established, recent research has demonstrated associations between deforestation and acute respiratory infection (Pienkowski et al., 2017), malaria (Austin et al., 2017; Bauch et al., 2015; Berazneva and Byker, 2017; Stefani et al., 2013) and diarrheal disease (Berazneva and Byker, 2017; Johnson et al., 2013). Although forests and forest-based ecosystem services are increasingly acknowledged as important factors in relation to healthy and sustainable diets (Brown et al., 2014; Dounias and Froment, 2011; Golden et al., 2011; Ickowitz et al., 2016, 2014; Pienkowski et al., 2017; Powell et al., 2015; Rowland et al., 2017; Vinceti et al., 2013; Vira et al., 2015), surprisingly few empirical studies have examined the ways in which deforestation affects diet quality and nutrition. In the context of climate

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https://doi.org/10.1016/j.healthplace.2018.03.002
Received 7 December 2017; Received in revised form 26 February 2018; Accepted 4 March 2018

change, growing population pressures, increasing demand for food, and widespread undernutrition, there is an increasingly urgent need to address this knowledge gap (Bain et al., 2013; Whitmee et al., 2015). Furthermore, such knowledge is particularly crucial for informing the design of programs and policies at local, regional and national levels to address the underlying determinants of poor quality diets and malnutrition in SSA.

Childhood undernutrition is a priority health issue in SSA where as many as 56 million preschool-aged children are chronically undernourished, approximately half are at risk of blindness due to vitamin A deficiency, and more than three-quarters suffer from iron deficiency anemia (Bain et al., 2013; Cordaro, 2013). Poor quality diets, that is, diets that lack diversity and do not provide an adequate, bioavailable supply of essential micronutrients, are an important cause of undernutrition (Black et al., 2013). Diet diversity is a proxy indicator of diet quality that is associated with the nutrient adequacy of child diets (Ruel, 2003; Torheim et al., 2004) as well as the nutritional status of children (Arimond and Ruel, 2004). The quality of complementary foods fed to children in the first two years of life is particularly important given the long-term impacts on health and development caused by early-life undernutrition (Hoddinott et al., 2013).

1.1. The potential links between forest loss and healthy child diets

The conceptual relationships between deforestation and the quality of children's diets are complex, often contradictory, and likely mediated by a range of socio-economic and contextual factors (Ickowitz et al., 2014; McMichael, 1999; Myers et al., 2013). The following paragraphs and Fig. 1 summarize the hypothesized links between forest loss and child diets drawing on the literature. The most direct pathway through which deforestation can affect child diets is via the reduced availability and consumption of local and affordable forest foods (i.e., uncultivated foods collected and/or hunted from biodiverse forested areas). Foods derived from forests are commonly consumed around the world though the extent of consumption and the contribution of these foods to diets varies considerably across social-ecological settings (Broegaard et al., 2017; Colfer et al., 2006; Food and Agriculture Organization of the United Nations, 2013; Powell et al., 2015; Reed et al., 2017; Rowland et al., 2017; Sunderland, 2011; Vinceti et al., 2013). The provision and availability of forest foods is particularly important in rural areas in communities living in proximity to intact forests but with poor market access (Harris and Mohammed, 2003; Ickowitz et al., 2016). Forest foods such as nuts, fruits, and bushmeat tend to have high nutritional quality (Food and Agriculture Organization of the United Nations, 2013; Powell et al., 2015). Therefore, the loss and degradation of forested landscapes may reduce access to diverse, affordable, and nutritious foods with negative impacts on micronutrient intake and overall diet diversity (Boedecker et al., 2014; Ickowitz et al., 2014; Rowland et al., 2017). Moreover, access to forest foods may be an important 'safety net' when other sources of food become scarce (e.g., during times of low agricultural outputs, droughts, and other extreme events) (Harris and Mohammed, 2003; Powell, 2012). The loss and degradation of forested landscapes could remove this 'safety net' thus negatively impacting the quality of diets, particularly among vulnerable populations like landless families, women, and children.

Deforestation could also lead to negative impacts on child diet quality and diversity by reducing agricultural practices that are more likely to produce diverse and high quality foods. There is some evidence to suggest that agricultural practices that are dependent on trees and forests, agroforestry for example, produce diverse and high quality foods with positive impacts on child diets and nutrition (Ickowitz et al., 2016; Pimentel et al., 1997; Reed et al., 2017; Vinceti et al., 2013). Biodiverse landscapes, at both the farm and ecosystem scale, have been linked to the production of a greater diversity of food (Herrero et al., 2017), and to more diverse household- and individual-level diets (Jones, 2017).

As Hansen (2013) outlines, "changes in forest cover affect the delivery of important ecosystem services, including biodiversity richness, climate regulation, carbon storage, and water supplies" (Hansen et al., 2013). The impacts of ecosystem services on food and agricultural is another important pathway through which the loss of forests and trees can influence diets. Loss of forest cover is in fact a proxy for degraded environments and loss of ecosystem services (Johnson et al., 2013). Given the myriad ways in which ecosystems contribute to both agriculture and human health, it is likely that the loss of ecosystem service provision resulting from deforestation could contribute to negative impacts on diets, particularly among vulnerable populations such as children (Reed et al., 2017).

Deforestation could also influence diet quality and diversity among children indirectly via the reduced availability of fuelwood for cooking. Access to fuelwood for cooking is an often-overlooked necessity for healthy diets. Approximately 2.4 billion people use fuelwood for cooking and preserving foods; populations across SSA are particularly dependent on fuelwood for cooking (Brown et al., 2014; Food and Agriculture Organization of the United Nations, 2013; Openshaw, 2011). Deforestation, alongside other forms of land-use change, reduces the availability of fuelwood and other biomass for cooking (Brown et al., 2014). Gathering fuelwood is a major burden on women's time and living in deforested areas has been shown to increase time allocation to gathering fuelwood for cooking (Brown et al., 2014; Jagger and Shively, 2014). Devoting large amounts of time to gathering fuelwood for cooking detracts from time available for food preparation and caring for children, which could adversely affect child diets (McGuire and Popkin, 1989).

Another possible indirect pathway through which the loss of forest and forest biodiversity could impact dietary quality and nutrition is through loss of income. The collection and sale of forest foods and other non-timber forest products (NTFP) can be an important source of

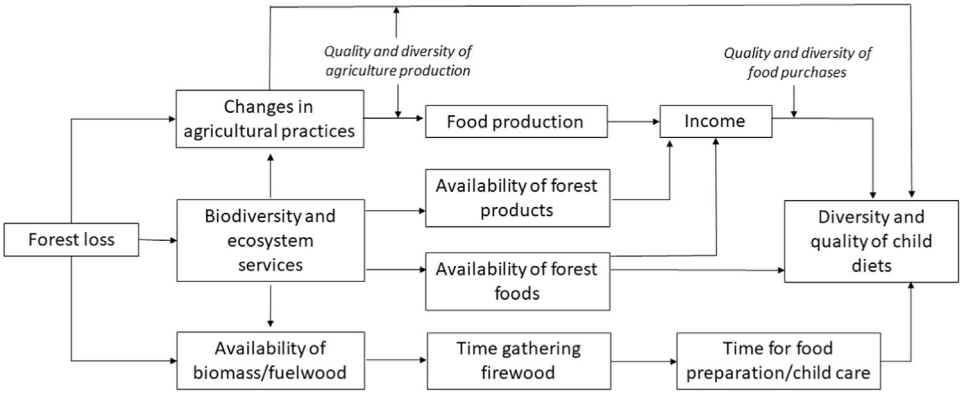

Fig. 1. Conceptual framework illustrating hypothesized links between forest loss and diets.