# LOSS OF POLLINATION SERVICES AND IMPACTS ON HUMAN NUTRITIONAL HEALTH: A COMPARISON BETWEEN LOW-INCOME AND HIGH-INCOME COUNTRIES OF THE WORLD.

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## Abstract

Human activities are affecting natural ecosystems and endangering the services they provide, with severe consequences for human health. Pollinators, including insects like bees as well as birds and mammals have been experiencing particular declines. Over the past decade, studies reveal that the number and species diversity of both managed and wild pollinators have continued to decrease and these declines are of direct concern for human health. The activities of pollinators are crucial for growing crops, in other words, pollinators contribute to crop yield and a great percentage of global food production. They are also responsible for the global supply of certain nutrients including vitamin A and folic acid, which are important for healthy growth and development. Pollinator loss could therefore not only reduce nutrient intake, but also threaten population health. This short thesis reviewed previous studies that estimated the effect pollinator declines might have on human health by examining impact on food and nutrient intake in low-income countries and high-income countries of the world. The hypothesis posed for this study attempts to resolve the varied nutritional health effects of pollinator declines among regions and countries of the world.

## Introduction

The value of pollination services supplied by insects was estimated at US$215 billion in 2005 and this contributes to about 75% of global crop species and enable reproduction in about 94% of wild flowering plants (Vanbergen 2013). This is also associated with an estimated agricultural yield of 35% global food production. While pollinator populations shrink in many regions, this threatens human food supplies and ecosystem functions. (Vanbergen 2013).

In the face of climate change, intensified land-use, alien species and the spread of pests and pathogens, pollinator species and habitats are severely affected (Potts et al. 2010); with serious implications for food security and human health. Global decreases in the number, range and diversity of both wild and managed animal pollinators have been confirmed. In developed regions of the world where managed pollinators are becoming increasingly important for crop production as a result of the decline of wild pollinator populations. There are significant decreases in non-managed pollinator populations and important variations in these declines among regions. Recent studies have confirmed that managed honey bee colonies in North America have seen more significant losses than European honey bee colonies (Smith et al. 2015). As well as for non-managed wild pollinators, significant declines over the past three decades have been documented throughout North America, Europe, Asia and Africa. There is a concrete evidence that the world's bird and mammal pollinator species have experienced increasing scarcity, extinction and narrowing ranges over the past 25 years (Smith et al. 2015).

Wild pollinators thrive in natural ecosystems and they provide resilient and complementary pollination services that support crop growth and yield (Kremen et al. 2002; Carvalheiro et al. 2011; Garibaldi et al. 2011). With increasing demand for pollinator-dependent crops and as pollinator abundance persistently fall, the risk of crop shortages and food insecurity increases.

This problems ensue in the absence of compensatory technical or economic responses (Vanbergen 2013). Further leading to unavoidable health impacts. Human health impacts of pollinator declines are magnified in developing countries, where the yield of insect-pollinated crops (e.g. beans) which supply crucial calories, vitamins and nutrients, are greatly affected. Nutrient deficiencies is common in many parts of the world, especially in developing countries. Pollinator-dependent plants provide 70% of essential micronutrients like folate and vitamin A which are vital nutrients for children and pregnant women. Inadequate intakes can lead to increased deaths from infectious diseases and increased incidence of blindness, short-sightedness and neural tube effects (Eilers et al. 2011). According to the World Health Organization, the maternal mortality ratio in developing countries in 2015 is 239 per 100 000 live births compared to 12 per 100 000 live births in developed countries. This is associated with nutrient insufficiencies in pregnant women during the stages of pregnancy, childbearing and the breast-feeding stage. Furthermore, the FAO estimates that about 840 million people do not receive enough energy from their diets to meet their needs. The overwhelming majority of these people (799 million) live in developing countries. An estimated two billion people or even higher are affected by micronutrient deficiency (FAO, 2002).

Recent studies have shown that areas of pollinator importance tend to occur within countries of high micronutrient deficiency (Chaplin-Kramer R et al. 2014). Insufficient intakes of pollinator-dependent foods, e.g. fruits, vegetables, nuts, and seeds increases the incidence of non-communicable diseases, also including cardiovascular diseases, diabetes, oesophageal and lung cancer (Lims et al. 2010). Good quality health relies on the roles of pollinators in sustaining crop production and yield.

## Research Hypothesis

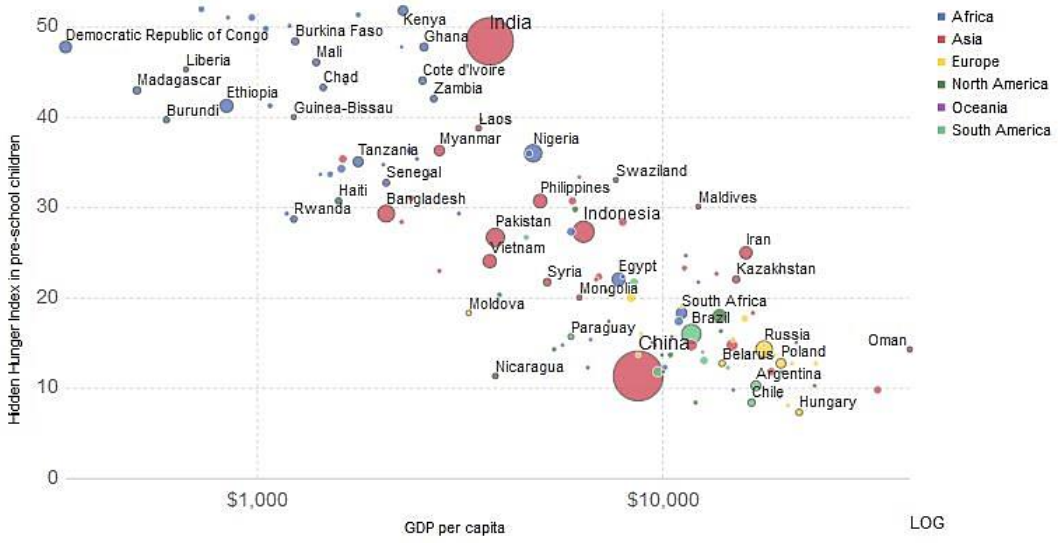


Figure 1: Hidden Hunger Index and GDP per capita, 2011. Source: https://ourworldindata.org/micronutrient-deficiency

In the chart above, the Hidden Hunger Index in pre-school children (HHI-PD) was plotted against gross domestic product (GDP) per capita, measured in 2011 in dollars. We see that countries with lower GDP per capita experience more severe deficiency and malnutrition issues. The HHI-PD is an index of three deficiency prevalence estimates: preschool children affected by stunting, anemia due to iron deficiency and vitamin A deficiency. A higher index value indicates more severe nutritional deficiencies. At the extreme top-left corner, there is the Democratic Republic of Congo (DRC) with the highest HHI-PD value and the lowest GDP per capita while on the extreme bottom-left corner, we have Hungary with the lowest HHI-PD value and among the highest GDP per capita.

More recent studies have estimated that 69 percent or more of the vitamin A in children diets came from fruits and vegetables, many of which depend strongly on pollinators (e.g. Ellis et al. 2015). Furthermore, they've shown that areas of pollinator importance occur within countries of severe micronutrient deficiency.

Therefore, based on relevant information acquired from these studies, the current study hypothesized that "Loss of pollination ecosystem services would have greater influence on human nutritional health in developing countries (low income countries) than developed countries (high income countries) of the world."

## Study findings

The IPBES pollination assessment report confirms that loss of pollinators leads to lower availability of crops providing essential micronutrients such as vitamin A, iron and folate leading to significant impacts on health, nutritional security and risk of nutritional deficiencies. The report also recognized animal pollination as a provider of multiple benefits to people in the form of medicines, biofuels, fibres, construction materials, musical instruments, arts and crafts. Many rural economies in developing countries favour beekeeping and honey hunting and a good quality of life for many people in these areas relies on the ongoing roles of pollinators as globally significant heritage (IPBES, 2016).

Few studies have assessed the potential effect of pollinator decreases on human nutritional health globally (Smith et al. 2015). But more studies have examined this topic on a more regional and local scale. Ellis et al. (2015) was the first empirical test on how losses in pollination influence nutrient intake and risk of nutrient deficiency. The study was restricted to women & children in four developing countries, namely Bangladesh, Zambia, Uganda, and Mozambique, and tried to assess the increased risk of micronutrient deficiency following pollinator removal in these four countries. These developing countries were selected as an attempt to study areas where high rates of malnutrition and limited access to nutrient supplements makes individuals more susceptible to the effects of pollinator declines. Their results suggest a highly variable but important role for pollinators in human nutrition in the developing world. The study's findings showed that human vulnerability to micronutrient deficiencies due to decreases in animal pollinator requires that the population receive significant nutritional value from pollinator-

dependent crops and that the population be near a threshold of dietary intake at which decreases would affect risk for deficiency.

Caulfield et al. 2004 used global agricultural production maps coupled with nutrient densities to investigate the relationship between reliance on pollinator-dependent crops and prevalence of micronutrient deficiency, finding that those at risk for pollinator-related nutrient losses are commonly also the most deficient. Further analysis suggests that areas where individuals rely more on pollinator-dependent crops and experience micronutrient deficiencies as a result of pollinator decline, and are usually low-income countries where there is no possibility to derive nutrients from other sources.

Smith et al. 2015 estimated the effect pollinator declines might have on human health by modelling impact on food and nutrient intake, providing the first global analysis of its kind. The study assembled a database of supplies of 224 different food types in 156 countries, based on 2009 FAO data. To estimate the reductions in nutrient and food intakes caused by pollinator declines, they quantified the nutrient composition and pollinator dependence of the foods.

To assess reductions in nutrient and food intakes as a result of pollinator declines, they estimated the nutrient composition and pollinator dependence of foods that were considered in their study. Their findings suggest that if all pollinators were eliminated, global fruit supplies would decline by 23%, vegetables by 16% and nuts and seeds by 22%. Where 71 million people in low-income countries would become deficient in vitamin A and a further 2.2 billion consuming below the average would experience further declines in supply, most especially in Central & Southern Africa and Southeast Asia regarded as ‘at-risk regions’. Further analysis for folic acid suggest that 173 million people becomes newly deficient mainly in South Asia, with 1.23 billion people already deficient would experience further declines. These changes in food and nutrient intakes are linked to risk of three groups of diseases, namely non-communicable (non-infectious, chronic diseases such as cancer, diabetes and heart disease), communicable (transmissible diseases such as TB and influenza) and malnutrition-related (e.g. vitamin deficiencies like rickets).

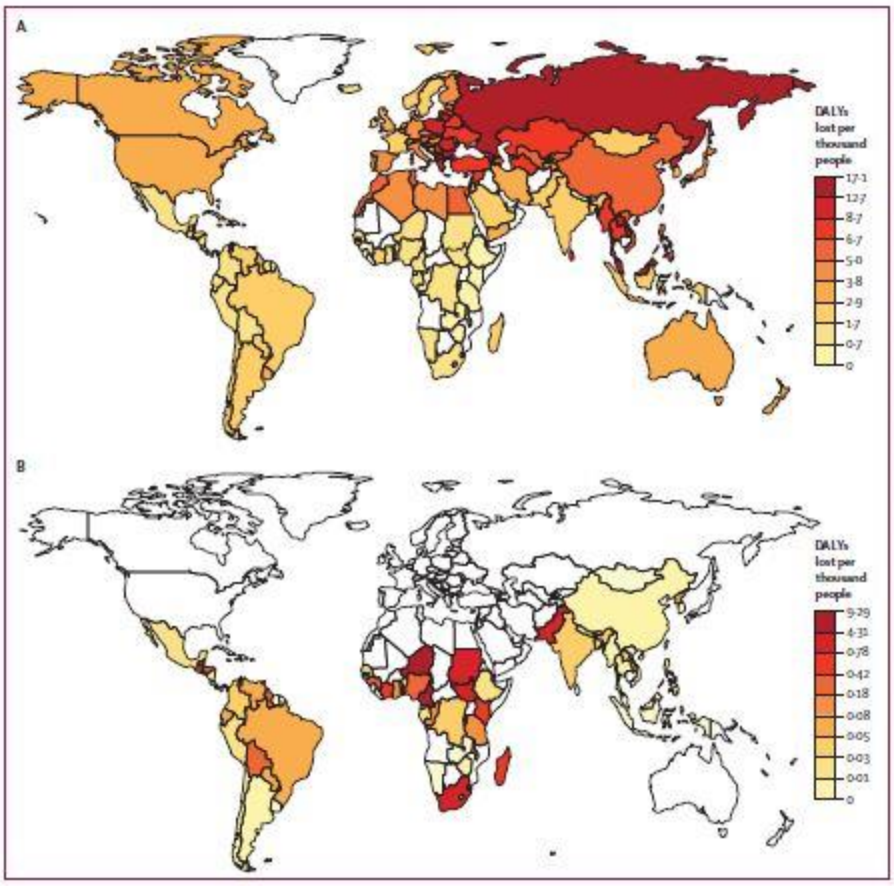


**Figure 2: Additional health burden from pollinator removal.** For (A) non-communicable cardiovascular disease, cancer, and diabetes, and for (B) malnutrition and communicable disease. DALY=disability-adjusted life-year. Source: Smith et al. 2015

For Figure 2a, the paper explains that the regions most vulnerable to increased non-communicable disease burden are in Eastern Europe, and Central, Eastern and Southern Asia. These countries tend to have high prevalences of chronic and metabolic diseases and depend more heavily on pollinator-related fruits, vegetables, nuts and seeds.

Conversely for Figure 2b, the largest increases per person in communicable and malnutrition related disease burdens related to pollinator loss disproportionately occur in low-income countries in Sub-Saharan Africa, South Asia, and parts of South America.

Furthermore, the authors recommend management strategies that could be implemented (especially in vulnerable nations) to solve the problems of pollinator declines. They cite the EU, which has restricted use of neonicotinoid pesticides and promoted natural beekeeping practices, as an example. By revealing the potential impact of and national vulnerabilities to pollinator decline, the study of Smith et al. 2015 helps policymakers to make decisions about which strategies to employ in tackling pollinator declines and where to apply them.

## Conclusions

Based on a few research papers that were reviewed, the study arrives at the following conclusions:

1. Major areas of micronutrient deficiencies are found in developing regions of the world, e.g. Sub-Saharan Africa and Southeast Asia.
2. Loss of pollination services have greater impacts on the nutritional health of low-income countries than high-income countries, because high income countries are capable of effectively managing their local pollinator population.
3. Pollinator-related losses of foods and micronutrients have the potential to substantially increase the burden of diseases from non-communicable diseases and micronutrient deficiencies around the world.
4. Policy makers in countries at risk of pollinator declines might address this vulnerability by implementing management strategies to ease the burden
5. In high income countries, such management approaches are already in place. Examples are:
    - The US government proposing to help pollinators through expansion of protected habitat for wild pollinators and increased study of environmental and anthropogenic stressors of the country.
    - The European Union focusing on restricting the use of pollinator-harming neonicotinoid pesticides and promoting national agriculture programmes.

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