Pollination and International Development: How bees can help us fight poverty and feed the world

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Abstract

While pollinator declines and their impacts on agriculture and natural ecosystems have received a great deal of attention in developed parts of the world such as Europe and North America, these issues are much less studied in developing countries, particularly across Africa. However, there is reason to believe the consequences of pollinator decline could be at least as detrimental to economies, ecosystems and communities in these regions. Pollinator declines have the potential to negatively affect communities in developing countries in a variety of ways, from reducing crop yields and value of crop products, to increasing the volatility of food prices, reducing access to micronutrient supplies and threatening income from honey production. Existing research into these issues has the potential to inform international development work. However, for optimum impact, different academic disciplines and institutes would work together to identify research needs and opportunities for collaboration and capacity building. It is also important that this information is reaching the relevant stakeholders – farmers, extension workers, beekeepers and policy-makers - in an accessible format.

Introduction

More than three quarters of global food crops rely to some degree on animal pollination (Klein *et al.* 2007). The benefits that animal pollination brings to these crop products, in terms of increased yield, quality and even longevity makes this service worth between US$235 and $577 billion annually (Lautenbach *et al.* 2012). Aside from these functional and monetary values, pollinators also have important cultural value, acting as a source of inspiration in art, music and folklore (IPBES 2016).

Evidence of severe pollinator declines in various parts of the world has stimulated a wave of international attention and concern, as well as scientific research. However, the majority of this research has been restricted to the developed world, particularly North America and Western Europe (Figure 1). This strong geographic knowledge bias is a concern because there is reason to believe the consequences of pollinator decline may be at least as serious in the developing world, for a number of reasons discussed here.

Through a review of the available literature and consultation with a range of stakeholders in this field (including academics, funders and practitioners), we explore the links between pollination and international development. We summarise existing work in this field, highlighting what is known and what is yet to be discovered and implemented; and identify knowledge, capacity, and policy needs for optimal development outcomes. This includes progress towards the following United Nations Sustainable Development Goals: 'No Poverty', 'Zero Hunger', 'Good Health and Well-Being', 'Sustainable Cities and Communities', 'Responsible Consumption and Production' and 'Life on Land'.

Why pollination is important to international development

Crop yields

Declines in pollination services have the potential to greatly impact upon the income and livelihoods of developing communities through reducing crop yields. Over 2 billion people in developing countries are smallholder farmers (Lowder *et al.* 2014), often heavily reliant upon pollinators, without necessarily knowing it. Indeed pollination deficits (reduced yield as a result of insufficient pollination) have already been identified in various studies across the developing world (Garibaldi *et al.* 2016; Samnegard *et al.* 2016).

Some of the most valuable cash crops, such as coffee, cocoa and cashew nuts are highly pollinator-dependent and almost exclusively grown in developing countries, providing communities with important income. Cocoa for example, provides a source of income for over five million smallholders in the tropics and represents 13.4% of the Ivory Coast's GDP (Hoare & King 2017). Global reliance on pollinator-dependent crops has increased fourfold in the last 50 years and most of this increase comes from developing countries (Aizen & Harder 2009) (Figure 2). Indeed, the relative economic impacts of pollinator losses on human welfare are expected to be greatest in western, northern and central Africa (Bauer & Wing 2016). With reducing yields of these pollinator-dependent crops, the land required to meet agricultural demands is also expected to increase, a trend that will be most pronounced in the developing world (Aizen *et al.* 2009).

The lack of economic support systems for farmers in the developing world - insurance packages, financial savings and the ability to take out loans - further increases their vulnerability (Harvey *et al.* 2014). It reduces their ability to buffer fluctuations in crop yields or prices and prevents them from switching to new farming systems (e.g. less pollinator-dependent crops) or investing in new technologies and agricultural inputs (Karlan *et al.* 2012), for example hiring managed pollinators.

Human health

With declining pollination services, not only would calorie intake and income fall, but the balance of people's diets is likely to shift. Some of the most nutritionally important food groups such as fruit, nuts, seeds and vegetables are also the most pollinator-dependent. According to Smith *et al.* (2015), severe pollination declines are therefore predicted to cause many millions of people around the world, and particularly in developing countries, to become newly deficient in important micronutrients such as vitamin A, vitamin C, iron and folate. Complete loss of animal pollination is expected to result in an additional 1.42 million deaths each year as a result of preventable diseases, and 29 million years of healthy life lost (Smith *et al.* 2015). It is clear that much of the burden of disease is a result of pollinator declines within a country, rather than cross-border (imported) pollinator declines, suggesting national-level strategies could be effective in mitigating these threats.

The overlap between malnourished areas of the world and pollinator-dependent micronutrient production (Chaplin-Kramer *et al.* 2014) suggests global malnutrition is likely to be compounded by

pollinator declines. This may have implications for meeting the UN Sustainable Development Goal of 'Good Health and Well-Being'.

Beekeeping

In addition to these benefits derived through crop pollination, certain bees also produce valuable products such as honey and beeswax which can generate a steady and significant source of income for rural communities, requiring few financial inputs. Income generated from beekeeping can have a number of important economic spin-off effects. Research has shown that extra money derived from beekeeping is often used to invest in new agricultural products or technologies, educate children or expand an existing business, helping to lift people out of the 'poverty trap' (J. Lowore 2018, personal communication, 29 March). In this sense, the development impacts may reach far beyond a bit of extra income. Beekeeping can also have important cultural benefits such as the empowerment of women, youth employment and creating social structures such as beekeeper associations (IPBES 2016). Keeping bees in orchards has also been shown to increase crop yields and quality, for example cashew orchards in Ghana benefitted from a two-fold increase in yield as well as a two-fold increase in quality when beehives were placed in the fields. This resulted in a 320% increase in the farmer's annual income, when income from honey production was also taken into account (Aidoo 2014).

Indirect benefits

Less tangible, but no less important is the cultural significance of pollinators in many parts of the world (Potts *et al.* 2016). Local knowledge and traditions relating to pollinators can be extensive (Lyver *et al.* 2015) - something that should be taken into account and perhaps utilised when studying pollinators in these countries. And because up to 90% of wild plants are at least partially dependent on animal pollination (Ollerton *et al.* 2011), many important medicines, foods, building materials and fibres derived from wild plants are also at threat from pollinator declines (IPBES 2016).

Analysis and reflections

Threats facing pollinators

While the importance of pollinators in the developing world is clear, it is difficult to assess whether population declines are occurring in these regions. Due to limited resources and capacity, most developing countries are lacking baseline data and monitoring programmes for pollinators. This makes it difficult to determine population trends in these countries. But from various studies showing local declines and extrapolating from regions where many of the same threats exist, declines seem likely.

Although agriculture is generally less intensive in the developing world (particularly Africa), with smaller fields and lower inputs of fertilizer, pesticide and mechanisation (Binswanger-Mkhize & Savastano 2017), this is likely to change. With rapidly-growing human populations and rising per-capita demands, agriculture will have to intensify, particularly in the developing world (Green *et al.* 2005). Removal of natural habitat - particularly forest which appears to be more important for pollinators in the tropics than in temperate areas – is a rapidly growing threat in these regions. In developing countries, a further 120 million hectares of natural habitat is predicted to be converted to farmland by 2050 (FAO 2009). The use of poor-quality generic pesticides is rapidly increasing across the developing world, particularly in sub-Saharan Africa (Popp *et al.* 2013). In South Africa for example, pesticide use was found to be associated with declines in floral visitors to mango

plantations and a resulting decrease in fruit production (Carvalheiro *et al.* 2010; Carvalheiro *et al.* 2012).

Understanding the nature of these agricultural changes and how they will affect pollinators may help mitigate some of the negative effects. However, because of the regional knowledge bias in pollination science, there isn't always the locally relevant research and information available to manage and mitigate these threats across much of the developing world.

Knowledge gaps

Gaps in our understanding of pollinators, pollination and the ways in which we can conserve them provide a fundamental barrier to ensuring they can provide the maximum benefit to developing communities. Filling these knowledge gaps will therefore provide some progress towards addressing the UN Sustainable Development Goals. Topics in need of further research and capacity building in the developing world include (but are not limited to):

- Taxonomy of wild pollinators
- Abundance, distribution, population trends and ecology of wild pollinators
- Threats facing pollinators in the developing world
- Pollinator dependence of different crops
- Extent of pollination deficits and their causes
- How to manage wild pollination service provisioning
- How to utilise managed pollinators (e.g. honeybees) most effectively

Many of these knowledge needs will take years to address. In the meantime, it would be beneficial to take lessons from existing research, as well as utilising personal experience and local knowledge to start conserving pollinators and managing their services as soon as possible.

Development research opportunities

There are a number of important contextual differences between pollination and agriculture in the developed and developing worlds. This makes it difficult to apply what has been learnt from studies in Europe and North America to the rest of the world, but also provides a number of research opportunities to discover what works in Low and Middle Income Countries (LMIC). Firstly, farming differs greatly in terms of style and scale. More than 2 billion people in developing countries are smallholders (farming areas <2ha in size), representing 83% of the global agricultural population (Lowder *et al.* 2014; Steward *et al.* 2014). This scale of farming is largely neglected in the pollination literature (Steward *et al.* 2014), despite being relied upon by a majority of people in developing countries and producing around half of the world's food (Herrero *et al.* 2010). The yield gaps (unfulfilled potential for yield increases) in these smallholder farming systems are generally large, as a result of few agricultural inputs and limited education. This provides a lot of scope for ecological intensification (Gemmill-Herren *et al.* 2014). Ecological intensification is the process of increasing crop yields and farmers' livelihoods through optimal management of natural ecological functions and biodiversity, rather than chemical and technological inputs. It involves understanding and managing processes such as pollination, nutrient cycling and biological pest control to improve agricultural performance.

Education and capacity building

In order to understand and manage pollination more effectively, human capacity must be strengthened at various different levels, including farmers, extension workers, researchers and the general public. Perhaps most significantly, understanding of the process of pollination amongst

farmers in developing countries is generally low, with many farmers perceiving all insects as pests. Education programmes which teach farmers how to manage pollination and other agro-ecological processes may therefore allow them to increase their productivity without the need for financial, chemical or technological inputs. Agricultural training centres and extension work are the foundation of farmer education in the developing world. Their capacity to deliver training in pollination and other agro-ecological techniques will determine farmers' understanding of these topics.

Conclusion

Pollinator declines have the potential to impact upon the food production, livelihoods, health and cultural traditions of communities in developing countries. However, pollination research from a range of disciplines may offer ways of mitigating some of these negative effects and providing a number of development opportunities. For this to be effective, there must be dialogue between researchers from different academic disciplines and regions, as well as with practitioners from the development, conservation, beekeeping and agricultural sectors. This will allow the relevant information to reach those who are able to apply it on the ground, while also ensuring the knowledge needs of practitioners are able to inform future research.

International bodies such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Convention on Biological Diversity (CBD) and the Food and Agriculture Organization of the United Nations have engaged with many of these challenges and fostered a great deal of political, public and scientific interest in pollination. A number of opportunities are available to build upon this momentum and use academic research to inform on-the-ground initiatives such as farmer training and development projects. However, barriers to achieving this include a strong geographic knowledge bias in pollination research, a number of important knowledge gaps and limited research capacity across many regions. A key challenge for the research and development community will be to identify these knowledge and capacity needs and establish the most effective ways in which research and development expertise, funding and institutions can contribute to addressing them. Effectively tackling these challenges can provide progress towards the UN Sustainable Development Goals of 'No Poverty', 'Zero Hunger', 'Good Health and Well-Being', 'Sustainable Cities and Communities', 'Responsible Consumption and Production' and 'Life on Land'.

Figures

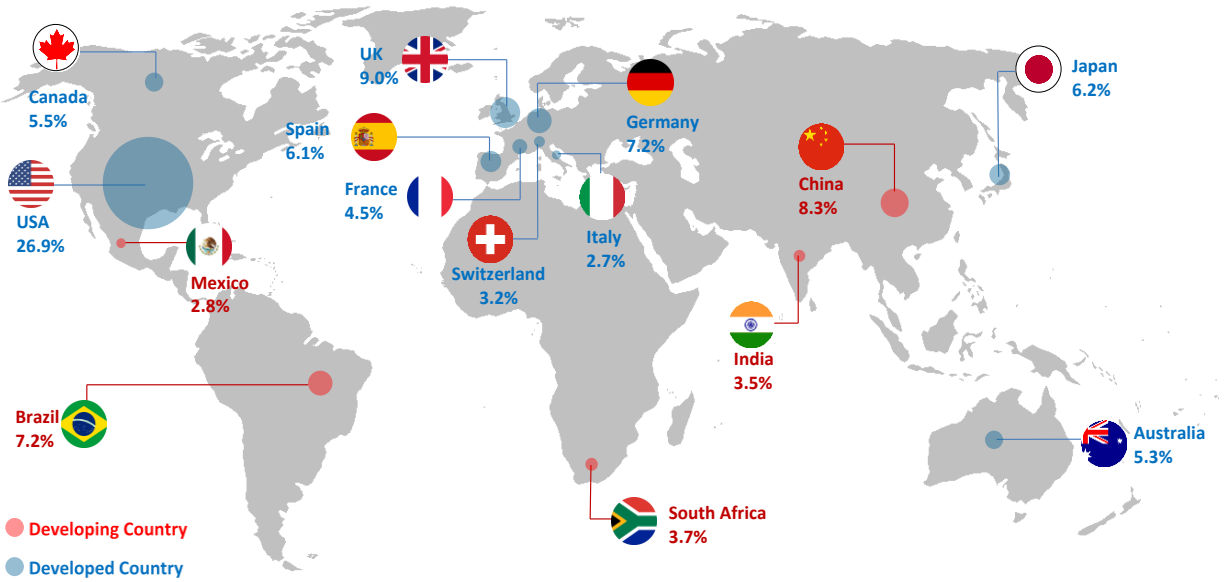

Figure 1. World map showing the top 15 countries contributing to pollination science papers between 1998 and 2018 (measured as number of papers co-authored by academics within each country). Note the imbalance between the 'Global North and South'. Source: Web of Science 2018

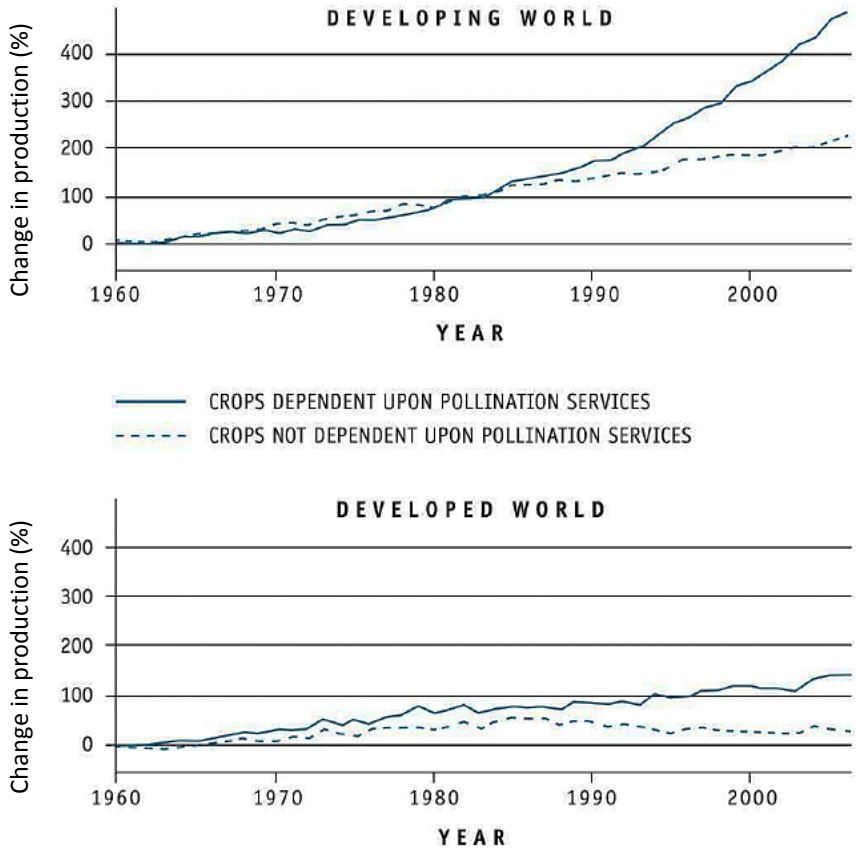

Figure 2. Temporal trends in pollinator and non-pollinator-dependent crop production in the developing world (top) and developed world (bottom) between 1961 and 2006. Production of pollinator-dependent crops in the developing world increased c. 5-fold over this period, compared with just a 1.5-fold increase in the developed world. This highlights the vulnerability of developing countries to pollinator declines. Figure from (Gemmill-Herren *et al.* 2014)

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Publication note

This paper is drawn from a technical report for the UK Collaborative on Development Research (UKCDR) on Pollination and International Development. The report draws upon the experiences of a range of academics, funders and practitioners working across various disciplines with relevance to pollination and international development. It also incorporates some of the outcomes and points of discussion from a Pollination and International Development Webinar hosted by UKCDR on 26 January 2018 and a Symposium on Research

in Beekeeping and Sustainable Development hosted by Bees for Development in March 2018. We are extremely grateful to all the consultees involved in this project.

To find out more, please see the full report, or listen to Tom Timberlake speaking on a Nature Xposed podcast about the importance of pollinators in developing countries.