Sustainable intensification of agriculture – the role of birds, bees and trees

1. Background

A. Introduction

Uganda's population is now above 34.5 million up from about 16 million in the 1991 (UBOS, 2002). The country's size and in particular arable land upon which people depend however remain constant and is seriously undergoing degradation. Increasing land productivity yet conserving biodiversity is a challenge Uganda has to meet to secure survival and wellbeing of its people and also the environment. To help determine approaches that would help enhance productivity per unit area of land while conserving biodiversity and consequently the ecosystem's ecological integrity and services (natural capital), two studies were conducted in the banana coffee zones(the most densely populated region) of Uganda.

This policy brief is based on results from research carried out between 2006 and 2008 under the project "Conserving biodiversity on the modernising farmed landscapes of Uganda". The project identified best practices for the long-term conservation of biodiversity in a sample of typical farmed landscapes in Uganda and established a framework for sustainable agricultural development and monitoring. The results can be used to support both policy and technological approaches to protect the environment and provide a basis for sustainable development.

B. Objectives of the previous project

The main objective of the project was to gather baseline information on patterns and trends in biodiversity in particular, birds, bees or other pollinators, butterflies, trees and other woody vegetation, in relation to agricultural land use in a range of smallholder and large-scale farming systems in the banana/coffee farming system of central Uganda.

The ornithological (birds) research, had the following main aims

(i) to assess the diversity and abundance of birds in agricultural landscapes

(ii) to relate temporal and seasonal patterns in the diversity and abundance to habitat characteristics

The entomological (insects) research had the following main aims

(i) to assess the diversity and abundance of butterflies and bees (insect pollinators) in agricultural landscapes along a management intensity gradient,

(ii) to relate temporal and seasonal patterns in the diversity and abundance to habitat characteristics

2. Methods of data collection

In this study, twenty-two small-scale mixed agricultural sites and four large-scale monoculture sites were surveyed for birds, bees, butterflies and tree density for a period of one year in 2006 and 2007. It involved counting birds, identifying bee species on 26 sites (1x1km square farmland plot) ranging from small scale farms to intensive plantations.

Birds, bees and butterfly species richness was counted as the total number of species recorded for each site and they were also classified according to their conservation status (whether they were species of conservation concern or not).

In addition to measuring biodiversity directly, the carbon load and pollination potential on each site was measured. The study was conducted in the banana/coffee arc around Lake Victoria, which is one of the major farming systems in Uganda.

3. Results

Pollination has a direct economic value through increasing the yield and quality of insect-dependent crops. In Uganda this includes coffee, tree, fruit and vegetables. In fact, of the 57 crops grown in Uganda approximately 47 (over 80%) of them require pollinators to set their fruit. Bees are the dominant taxa providing crop pollination services, but birds, butterflies, bats, moths, flies and other insects are also important for some crop/plant species. Coffee is Uganda's largest export crop and Uganda is ranked as 2nd in Africa and 7th in the world for coffee production (EAFCA, 2011). Central Uganda produces 0.314-0.489 million tonnes of coffee beans in total for a mean economic value of US$214 million from which US$149.42 million (62%) are attributable to pollination services delivered by bees (Munyuli, 2010). This is equivalent to 20% of annual earnings from export of agricultural products by government of Uganda and 2.99% of the GDP. The high economic value of pollination services highlights the need to develop and operationalize policy to sustain viable pollinator populations in agricultural landscapes of Uganda. However, with increasing agriculture intensification, there is a high risk of pollinator depletion leading to a decline in yields, crop failure and food insecurity.

A. Birds

The previous study found that retaining pristine forest areas whilst farming a separate area at high intensity results in higher densities of most bird species than land sharing, where a larger area of land is farmed at a lower intensity. The results also indicate that small-scale mixed farms have a higher bird species richness and bird densities than large-scale monoculture farms. Small-sized birds react more towards local-scale habitat changes while larger birds react more towards landscape habitat changes.

In total, 218 bird species were recorded during the counts. The numbers of species recorded in a single site ranged from 72 to 123 species.

Bird species richness decreased with increasing human population density and the proportion of cultivated land at the sites, but increased with increasing crop diversity. Species richness for species that are more sensitive to forest habitat loss; forest dependents, frugivores and nectarivores, increased with increasing numbers of trees at the sites, especially large trees and with increasing proportion of fallow land at the sites.

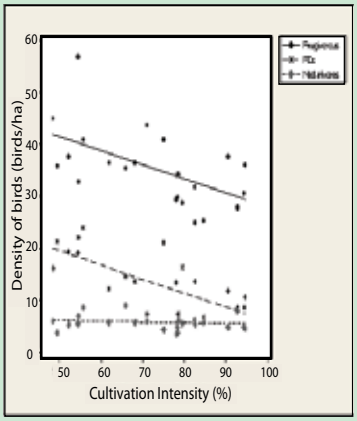

Figure 1: Relating Cultivation Intensity with the density of birds

	Local scale		Landscape	
	Small birds	Big birds	Small birds	Big birds
Fallow	0.164	-0.140	0.249	***0.736
	0.424	0.494	0.264	<0.001
Crop diversity	*0.487	0.089	0.275	-0.169
	0.012	0.665	0.215	0.451
Crop land	-0.153	0.176	-0.159	**-0.626
	0.456	0.390	0.480	0.002
Tree density	**0.546	0.149	0.127	0.219
	0.004	0.468	0.573	0.327

Table 1: Correlation of birds to local and landscape habitats

B. Bees and butterflies

Prior to this study, only c. 50 species of bee were known to occur in Uganda. This study recorded over 500 species, including some most likely new to science. The study found that bees are essential and vital in sustaining coffee production as they are the main pollinators of coffee which many Ugandan farmers depend upon for food security (Munyuli, 2010). Small-scale farmers obtain a yearly mean income (gross revenue) of US$900/ha coffee. The value of bees, or the economic profitability of pollinating services delivered by bees to coffee, was estimated to be US$650/ha/year on average in the Banana Coffee region between 2007 and 2008 (Munyuli, 2010).

The value of bees for a large coffee farm in the previous project was found to be higher if the farm was surrounded by a high amount of linear and non-linear semi-natural habitats (e.g woodland, hedges, unimproved pasture land, fallow land, woodlots, grasslands and tree plantations) and an increase of 40-100% of the density/ diversity of bees was associated with approximately 90% increase in the coffee yield, particularly for coffee fields near linear and non-linear habitats (Munyuli, 2010).

Bee species richness, diversity and abundance were all higher in sites with a higher cultivation intensity (proportion of agricultural land being actively cropped rather than be left fallow) and from other environmental data it was shown that non-agricultural habitat such as riparian forest patches and wetlands but also habitats that were part of the agricultural matrix such as forest fallows, tree lines and hedges around fields were important. The diversity of nesting sites and floral resources were therefore the main factors determining bee abundance/diversity. Similar results were obtained for butterflies such that species richness increased with increasing crop diversity and more fallow land

C. Trees

Carbon load decreased as intensity increased, especially within small trees as even on intensive farms large trees are often left to act as natural windbreaks. Pollination potential also decreased as cultivation intensity increased.

Generally, the most species-rich sites were those supporting small mixed agricultural holdings (or gardens, e.g. Katwadde, Kiwaala, Mpugwe and Kiweebwa) and the lowest number of species was recorded in two of the large-scale monoculture plantation sites (sugarcane and tea plantations).

4. Implications of results to policy makers, extension workers, farmers and other stakeholders

A. That Policy makers should:

- Develop a policy that enhances biodiversity conservation on farmland through guidelines such as agro-forestry, use of organic manure, crop Enterprise mix (term used by NAADS to mean intercropping/multiple cropping, row cropping etc. Others are putting land under fallow for it to regain fertility, reduced use of chemical pesticides and practicing sustainable water and soil management techniques
- Develop a policy which stresses use of indigenous species to control crop pest and diseases as an alternative to expensive and often indiscriminate use of pesticides and insecticides which are detrimental to these very species.
- Conserve significant proportions of natural and semi-natural ecosystems to provide habitat for a large diversity and density of pollinators
- Consider paying farmers who to carry out environmentally beneficial activities on their land, as is currently practised within the European Union, should be considered. These schemes are intended to reward activities that allow more sustainable productivity, such as creating wildlife corridors, leaving land fallow, reducing the use of chemical fertilisers and pesticides, establishing hedgerows and plantings native species that attract a range of wildlife.
- Policy and development packages should consider appropriate interventions to deliver access to credit, capital and assets. Access to financial services is often limited and small-scale farmers often face high interest rates and difficult borrowing conditions. Access to microfinance initiatives that include saving as well as credit options is required. In addition, better access to new research and technologies is required in highlighting the importance of extension workers.

B. Extension workers

- Encourage farmers to intensify agricultural production on existing farmed land to prevent further land conversion:
- Encourage farmers to practice guidelines that have been passed by policy makers
- Advice farmers to maintain a diverse array of wild plants to conserve the native plant species while also providing resources for many insects, specifically pollinators. This may involve a specific programme to allow farmers to breed, select, produce and supply the seeds they require as occurred in the past but is now under threat due to international intellectual property regulations.
- Raise the level of knowledge of awareness about the different tree species to be planted to provide shade to coffee and associated crops. Shade contributes to the increment of coffee yield by favouring several other factors directly involved in yield increase such as attracting a diverse and rich bee fauna. Also, it has been evidenced that coffee plantations grown under good shading regimes attract efficient pollinator species. Most social bees (stingless bees) forage better and deliver pollination services to coffee trees located in farms with at least 10% to 50% shade cover (Munyuli, 2011).
- efforts should be in place to educate small-scale farmers to appreciate and know different pollinating agents of their important crops

C. Farmers

- Leave uncultivated areas around, and within, cultivated areas to allow grasses and other wild plants to grow in order to control soil erosion and encourage pollinators and beneficial insects.

D. Researchers

- Evaluate the effectiveness of current sustainability schemes (i.e. fairtrade, organic) which aim to reduce the use of chemicals, protect biodiversity and provide better prices for farmers. Further investigation into the ability of these schemes to scale up to regional levels rather than just a single farm is required.

5. Conclusion

Current agricultural intensification strategies of adding more fertilizer or relying on increased use of machinery no longer work in many areas due to soil degradation, and the increasingly unpredictable natural and economic environments means that farming is becoming even more challenging. For that reason, a new paradigm for agricultural research and development involving a diversity of approaches using a combination of scientific and indigenous knowledge is called for. This approach would ensure that we can sustainably manage our natural resources and produce resilient landscapes that offer a WIN-WIN situation for both human well-being and biodiversity.

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