Adaptation of society confronted with a pollinator decline:

A local market analysis

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Abstract

Insect pollination service is a significant ecosystem service, as it has a double contribution to our society. Firstly, it has a biological contribution since it actively contributes to crop and wild flora production. Secondly, it contributes economically. But insect pollinators are declining. In this paper we develop a framework and analyse the impact of a pollinator decline on the social welfare. We modelized a local economy composed of an agricultural sector and a non agricultural one. The agricultural sector is composed of an insect dependent pollinator subector and a non insect dependent one. We also consider that consumers have strong preferences on insect pollinated goods. Then we observe the impact of an insect pollinator decline in this local economy in three scenarios: Business As Might Be Usual (BAMBU), Agricultural Market Liberalization (AML) and Green Agriculture (GA). We found that the intensity of the pollinator decline and the consequence in the social welfare vary following the political strategy of each scenario. Overall, the measure of the pollinator impact in our society is the result of several mechanisms that take into account interaction between farmers that produce insect pollinated good, farmers that produce not insect pollinated good, consumers that have preferences on insect pollinated good. The welfare decrease, in term of profits and in utilities, is higher in the AML scenario than the other one. The welfare loss is the lower in the GA scenario.

Keywords: Economic analysis, insect pollinator, ecosystem services, scenarios, agriculture

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1 Introduction

The economics of ecosystem services is an emerging area in economy (Gomez-Baggethun *et al.* 2009). The origins of the modern history of ecosystem services are to be found in the late 1970s - it started with the utilitarian framing of beneficial ecosystem functions as services in order to increase public interest in biodiversity conservation (Westman, 1977; Ehrlich and Ehrlich, 1981; de Groot, 1987). It then continued during the 1990s with the mainstreaming of ecosystem services in the literature (Costanza and Daly, 1992; Perrings et al., 1992; Daily, 1997), and with increased interest on methods to estimate their economic value (Costanza et al., 1997). Early 2000 several international projects were created bringing together researchers to evaluate the ecosystem services as the MEA (Millennium Ecosystem Assessment) and the TEEB (The Economics of Ecosystems and Biodiversity). There is also a fast growing body of literature in the economic valuation of ecosystem services (Fischer *et al.*, 2009).

Such interest for the economic valuation of ecosystem services is due to its implication to human welfare since ecosystem services denote the direct and indirect (free) contribution of ecosystem to human well-being (TEEB, 2010). Secondly, these services are increasingly under pressure, while the demand for them is increasing - , which led the researchers of the MEA to conclude that we are living an "ecological crisis" (MEA, 2005).

Insect pollination service is a significant example of an ecosystem service, as it has a double contribution to our society. Firstly, it has a biological contribution since it actively contributes to crop and wild flora production (Klein *et al.*, 2007). Secondly, it contributes economically: the contribution of insect pollination to world agricultural production amounts to €153 billion/year (Gallai *et al.*, 2009). The economic contribution is also perceived at the local scale since it contributes to the gross benefit of farmers (Ricketts *et al.*, 2004). But insect pollinators are declining (Biesmeijer *et al.*, 2006), which leads economists to the following question: what would be the impact of a pollinator decline on social welfare?

The measure of consumer and producer surplus is often used to evaluate social welfare. Southwick and Southwick (1992) and Gallai *et al.* (2009) evaluated the surplus losses that occurred subsequently to a pollinator decline. These studies introduced different assumptions on consumer preferences for goods that depend on pollinators: the stronger the preferences are, the more important the welfare losses are. However these studies that evaluate the social pollinator impact considered only one market: the agricultural market. What happens when there are many markets linked all together? What happens when consumers can substitute the pollinated good with a non-pollinator dependant good? Bauer et al. (2011) found that substitution abilities after a pollinator decline will reduce the social welfare loss. It could also lead to a higher social welfare following several hypotheses on technological capacities (Gallai *et al.* 2009).

However these studies are large scale or theoretical analysis that could not or with difficulty be applicable at a smaller scale, says "local economy" scale. We want to develop a model that would allow to analyse the insect pollinator contribution and the consequences of it declines on the society.

We develop three scenarios where we analysis the evolution of a two-sector local economy model: the agricultural sector and the non-agricultural one. The agricultural sector is composed of two sub-sectors, where one sub-sector depends on insect pollinators and the other one not. In the following part (part 2), we will explain our model. The results will be detailed in the part 3. A discussion of the results and conclusion will be held in part 4.

2 The model

2.1 Ecological considerations

The crop production of certain crops depends on insect pollination that is measured through a ratio called « dependence ratio » and for which we attribute the symbol $\overline{D}$, where $\overline{D}$ is comprised between 0 and 1 (Klein et al. 2007). Thus, insect pollinators contribute to $100*\overline{D}\%$ of the crop production, and inversely $100*(1-\overline{D})\%$ of crop would be produce without insects. We assume that this value of $\overline{D}$ represents the total production loss consequently to a total pollinator decline. We create a pollinator dependence function *D(.)* where $\overline{D}$ is the maximum value and 0 is the minimum value. The function *D(.)* depends on the abundance of pollinators, *A*, such as:

$$D(.) = \overline{D}(1-A)$$

where A is comprised between 0 and 1. When A tends to 0, it means that abundance of pollinators tends to be null and so on the production loss tends to be $\overline{D}$. Inversely, when A tends to 1, the pollinator abundance is high and the production tends to be null.

2.2 Economic model

We present a model of a local economy for which the social welfare, W, is measured through the sum of profits of firms f_i and utility of the N local consumers, U, such as:

$$W = NU + \Pi_1 + \Pi_2$$

2.2.1 The supply side

We consider a local economy with two sectors:

- The agricultural sector
- The non agroicultural sector

<u>The agricultural sector:</u>

Firms in the agricultural sector produce food. It is divided into two sub sectors, where the output is y_i, where i = 1,2 and the production function if f_i, where i = 1,2. Firms of this sector dedicate all their production for the local market. The first sub sector is composed of a represensatative firm f_1 that produce a pollinator-dependent output $y_1 = f_1(A,.)$ with $\delta f_1/\delta A > 0$. The second sub sector is composed of a representative firm f_2 for which production of y_2 does not depends on insect pollination.

The productions y_i are linear such as:

$$f_1(A, y_1) = (1 - \overline{D}(1 - A))y_1$$

$$f_2(y_2) = y_2$$

The production costs, c_i, are represented by the cost functions $g_i(.)$ that depends on capital, labor and land with $\delta g_i/\delta y_i > 0$ and $\delta^2 g_i/\delta y_i > 0$, such as:

$$g_i(K_i, L_i, T_i) = y_i^2\left(n_1 l_i + n_2 t_i\right) + K_i$$

where l_i and t_i are unitary costs of, respectively, labor and land use and n_1 and n_2 are parameters of costs. We assume that capital is a fixed cost.

The profit function of firms, for given prices of output (p_{f1} and p_{f2}) are denoted Π_1 for firm f_1 and Π_2 for firm f_2. Those function read as :

$$\Pi_1 = p_{f1}(1 - \overline{D}(1 - A))y_1 - y_1^2\left(n_1 l_1 + n_2 t_1\right) - K_1$$
$$\Pi_2 = p_{f2}y_2 - y_2^2\left(n_1 l_2 + n_2 t_2\right) - K_2$$

The optimal supply for subsectors 1 and 2 are represented by the following inverse supply functions:

$$p_{f_1}^* = \frac{2y_1\left(n_1l_1 + n_2t_1\right)}{(1-\overline{D}(1-A))}$$
$$p_{f_2}^* = 2y_2\left(n_1l_2 + n_2t_2\right)$$

<u>The non agricultural sector</u>

The non agricultural sector gathers all the firms that are not producing foods. The goods offer in this sector do not depend on insect pollination. We consider that the supply of this sector is unlimited and perfectly elastic. Furthermore the production is dedicated to local cosumers and to other consumers. We assume that production that is not sold to local consumers will be sold to consumers from outside the local economy considered here.

2.2.2 The consumption side

Individual consumer's preferences are represented by the combination of the utility, *u(M)* bring by the consumption of food, *M*, and the utility, v(x_3) bring by the consumption of all other goods called x_3. The food consumption *M* is a combination of food x_1 (that depends on pollinator) and x_2 (that does not depends on pollinator) weighted by the anchorage of preference, *a*, on x_1 as follow: $u(M) = M^{\frac{1}{2}} = \left(ax_1 + (1-a)x_2\right)^{\frac{1}{2}}$. The utility function, *v*, is a linear function such as $v(x_3) = mx_3$. The overall utility function is:

$$U\left(u\left(x_1,x_2\right),v\left(x_3\right)\right) = u\left(x_1,x_2\right) + v\left(x_3\right)$$

Consumers are constraint by the revenue, R:

$$R \geq p_1x_1 + p_2x_2 + p_3x_3$$

Consumers use their total income in order to maximized their utility. This end up in individual inverse demands, $p_1(R, x_1, x_2)$, $p_2(R, x_1, x_2)$ and $p_3(m)$:

$$p_1 = \frac{R - mx_3}{x_1 + \frac{1-a}{a} x_2}$$

$$p_2 = \frac{R - mx_3}{x_2 + \frac{a}{1-a} x_1}$$

$$p_3 = m$$

2.2.3 Partial equilibrium

There are three markets represented in this model. Two markets for the consumption of agricultural goods and one market for the non agricultural goods. All markets clear at the equilibrium, *i.e.* supply equals demand on each market :

$$\begin{cases} p_{f1}(A, y_1, K_1, L_1, T_1) = p_1(x_1, x_2, R, a) \\ p_{f2}(y_2, K_2, L_2, T_2) = p_2(x_1, x_2, R, a) \\ p_3 = m \end{cases}$$

The quantity exchanged at the equilibrium are x_1^* and x_2^* that solve the problem.

2.3 Scenarios

We will consider a small local communities of 100 persons. We will analyse the impact of a pollinator decline on the consumer welfare to consume food, u(.), following three prospective scenarios: BAMBU (Business As Might Be Usual), AML (Agricultural Market Liberalization) and GA (Green Agriculture) over the twenty next years. Each scenario is a storyline of a possible world where we describe the evolution of different parameters and analyse the impact on the main variables that are p_i, x_i, $u(p_i, x_i)$ and profit of firms.

The BAMBU scenario describes a futur world in the continuity of the one of today *i.e.* that the Common Agricultural Policy plays an important role for crop market stability, environmental protection and rural development. Thus prices of non agricultural goods will increase slowly over the time. Subsidies of the CAP is translate into a low increase of factor's costs. Nevertheless the pollinator abundance will continue to decline during this period.

The AML scenario is a kind of market liberalization scenario where the CAP will decrease it influence on the agricultural market. In order to be competitive, farmers increase their production and productivity. Consequently cost of inputs will increase very slowly. In counter part, farmers will use use more and more pesticide and land which will impact negatively pollinator abundance.

The GA scenario is based on an enforcement of the environmental part of the CAP. In the continuity of the Ecophyto policy, the farmers should produce without pesticide and no more land detruction. Consequently the pollinator abundance will not decrease or very slowly over time. However farmers will compensate these environmental constraints by using more inputs. Then the cost of inputs will increase.

2.4 Data collection

We modelized a french local economy. For that, we used Eurostat (2013) and Agreste (2013) databasis, in order to estimate the main parameters of the model. We calculated the 2011 dependency ratio, D, in doing the weighted means of french dependency ratio in using the FAO guidelines from Gallai and Vaissière (2009). In the calcul we used only the crops that depdends on pollinators. In the model, we consider that consumers have a strong preference on the insect pollinated goods. For the insect pollinator abundance index we consider that 2011 was the start year when abundance was 100%. Then we estimated different loss of abundance following figures from the findings of Brittain and Potts (2011) on the impact of pesticide on the pollinator loss.

Parameters	Description	Units	2011	BAMBU	AML	GA
				Variation per year		
R	Revenu	Euros per pers	26400	+5%	+2%	+10%
a	Anchorage of preference	[0 ; 1]	0.75	-	-	-
p_3	Price of non agricultural goods	Euros	100	+5%	+2%	+10%
D	Dependency ratio	[0 ; 1]	0.4	-	-	-
K_1	Total fixed cost of capital in insect pollinated dependent subsector	Euros	21730	-	-	-
K_2	Total fixed cost of capital in non insect pollinated dependent subsector	Euros	2208	-	-	-
l_1	Unitary cost of labor per kilogram of production in insect pollinated dependent subsector	Euros per kilogram	0.147	5%	+2%	+10%
l_2	Unitary cost of labor per kilogram of production in non insect pollinated dependent subsector	Euros per kilogram	0.001	5%	+2%	+10%
t_1	Unitary cost of land per kilogram of production in insect pollinated dependent subsector	Euros per kilogram	0.015	5%	+2%	+10%
t_2	Unitary cost of land per kilogram of production in non insect pollinated dependent subsector	Euros per kilogram	0.039	5%	+2%	+10%
x_3	Non agricultural good consumption	Quantity	2000	-	-	-
A	Insect pollinator abundance	[0 ; 1]	1	-5%	-20%	-2%
n_1	Technological parameter		1/100	-	-	-
n_2	Technological parameter		1/100	-	-	-

3 Results

The consumers of the local economy are caracterised by a strong preference on insect pollinated dependent goods. Thus the demand for this good is higher than for the other one. In the other hand the production cost for non insect pollinated goods is lower, which imply that the supply for good 2 is higher (Table 1). Consequently the price of insect pollinated good is higher than for the non one and the quantity exchanged into markets is higher for non insect pollinated good than for the pollinated one. In this theoretical local economy, the agricultural subsector that offers the insect dependent good gains compare to the other one. Furthermore the utility bring in consumming food is estimated to 15 700.

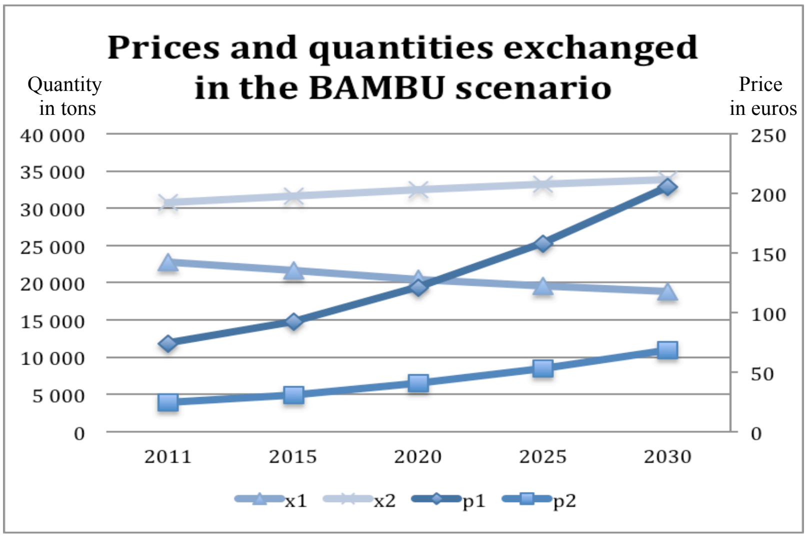
Variables	Values	Unit
Price of insect pollinated good, p_1	74	Euro per ton
Price of non insect pollinated good, p_2	25	Euro per ton
Quantity exchanged of insect pollinated good, x_1	22 790	Tons
Quantity exchanged of non insect pollinated good, x_2	30 766	Tons
Profit of insect pollinated good producer	819 649	Euro
Profit of non insect pollinated good producer	376 412	Euro
Utility of consuming food, $\underline{u}$	15 700	Euro

Table 1 – 2011 values of prices, quantity exchanged and profit in the local economy.

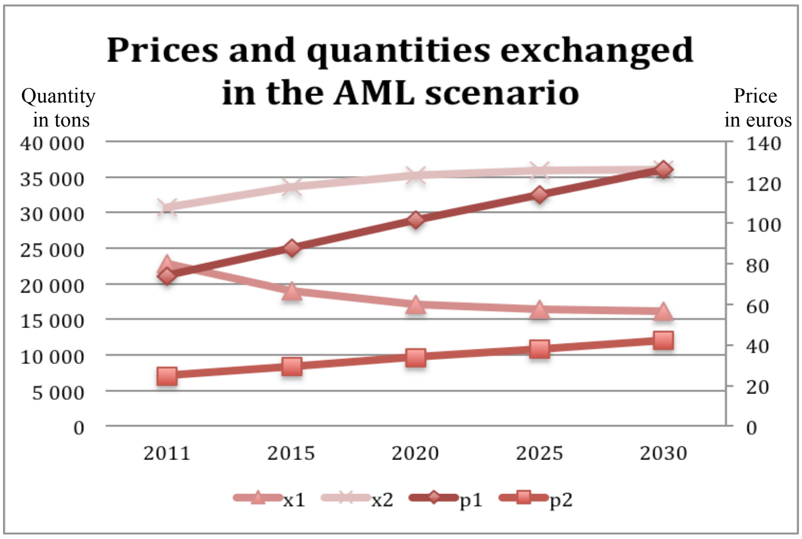
The prices of both goods, insect dependent and non dependent crops, will increase in all the scenarios (Figure 1). The larger growth will be in the GA scenario while the lower one will be in the AML scenario. The increase of prices has not the same intensity following the agricultural subsector. Indeed the increase of p_1 is higher than the one of p_2 in all scenarios. The larger difference between p_1 and p_2 is observed in the GA scenario while the lower one is observed in the AML scenario.

The quantity exchanged into markets vary following the subsector. Thus we observe that insect pollinated good exchanged decrease in time while that quantities exchanged for the non insect pollinated good increase (Figure 1). The higher decrease of x_1 and the higher increase of x_2, respectively -29% and +17%, are observed in the scenario AML. The lower decrease of x_1 and the lower increase of x_2, respectively -9% and +5%, are observed in the scenario GA.

A)


Prices and quantities exchanged in the BAMBU scenario
Quantity in tons
Price in euros
40 000
35 000
30 000
25 000
20 000
15 000
10 000
5 000
0
250
200
150
100
50
0
2011
2015
2020
2025
2030
x1
x2
p1
p2

B)


Prices and quantities exchanged in the AML scenario
Quantity in tons
Price in euros
40 000
35 000
30 000
25 000
20 000
15 000
10 000
5 000
0
140
120
100
80
60
40
20
0
2011
2015
2020
2025
2030
x1
x2
p1
p2

C)

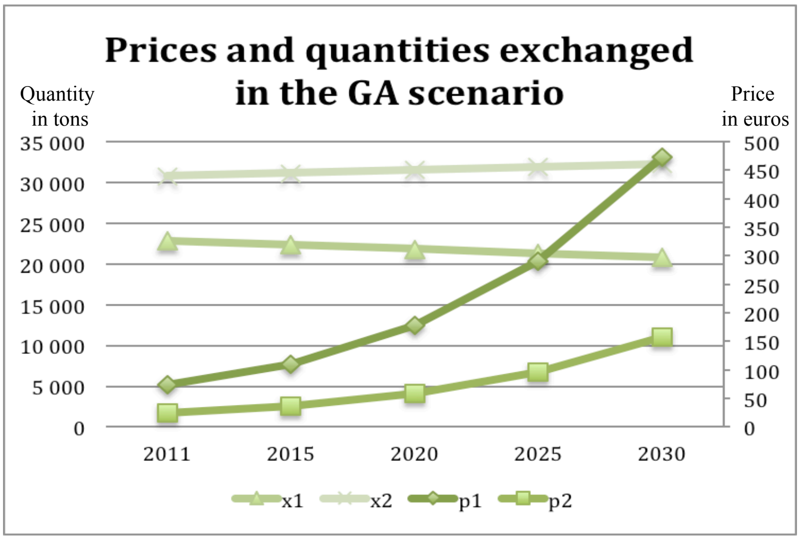

Prices and quantities exchanged in the GA scenario
Quantity in tons
Price in euros
35 000
30 000
25 000
20 000
15 000
10 000
5 000
0
500
450
400
350
300
250
200
150
100
50
0
2011
2015
2020
2025
2030
x1
x2
p1
p2

Figure 1 – Prices and quantities exchanged in the A) BAMBU, B) AML and C) GA scenarios

The production loss, that is relative to the insect pollinator loss index, A, between 2011 and 2030 within each scenarios is higher in the AML scenario and lower in the GA scenario (Figure 2). The convex form of the curves in the three scenarios suggests that the production loss is decreasing in time.

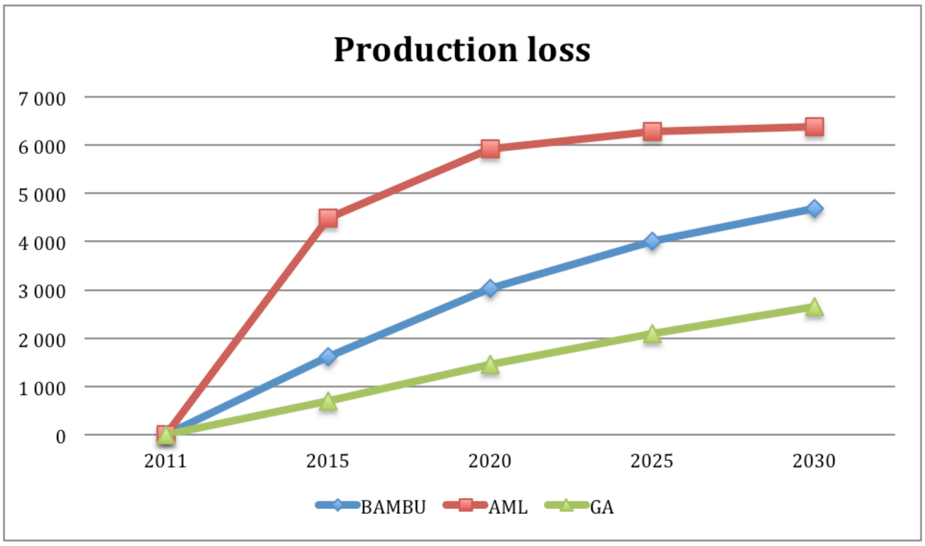


Figure 2 – Production loss due to insect pollinator decline in the BAMBU (blue curve), AML (red curve) and GA (green curve) scenarios

The GA scenario is the one where agricultural sector will gain the most. The second one is the BAMBU scenario and the worst one would be AML scenario. In the BAMBU scenario, the profit of farms of the pollinator dependent subsector will continue to gain (+74%) but relatively less that the farm of the other subsector (+206%, Figure 3). We observe approximately the same result, but not as much pronounced, in the GA scenario where profit of insect dependent subsector gain 421% and the other sector gain almost 580%. These two results suggest that the pollinator decline would impact the first subsector, what would be profitable for the non dependent on insect subsector. In the AML scenario the extreme case appears where 1) the farms of the insect dependent subsector see there profits decrease and 2) the farm of the non depend on insect subsector make more profit that the insect dependent subsector.

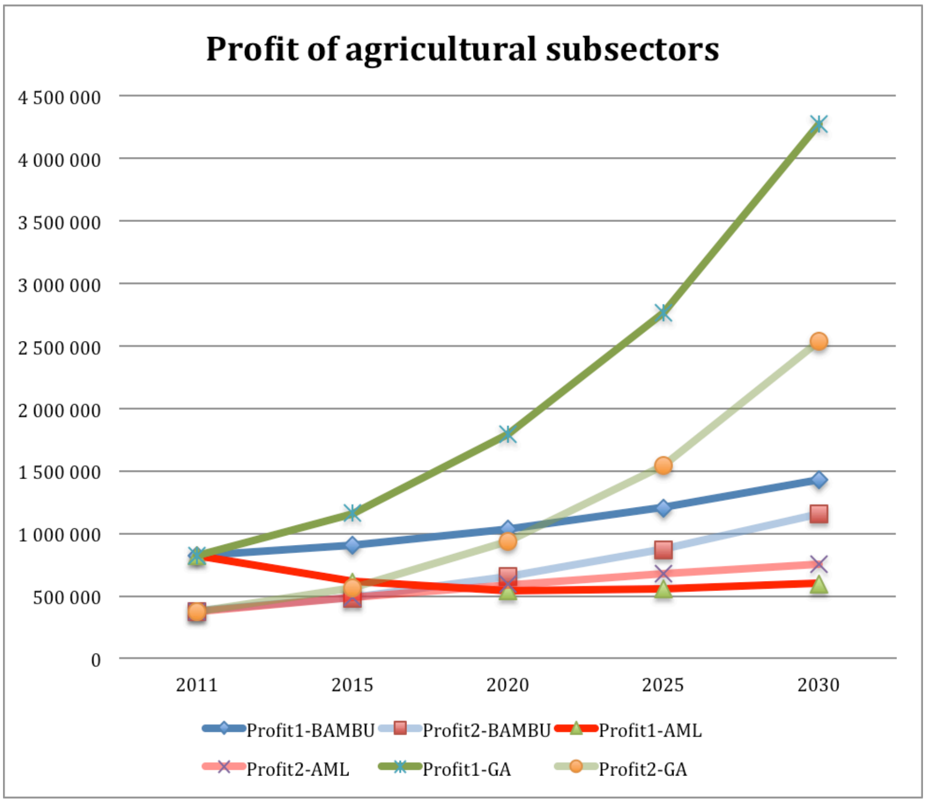


Figure 3 – Profit of agricultural subsector that depends on inect pollinators (Profit1) and that one that does not depends on insect (Profit2) in the BAMBU (blue curve), AML (red curve) and GA (green curve) scenarios.

The impact of the pollinaor decline in the utility bring by food consumption is negative for the three scenarios (Figure 4). The utility loss is the lower in the GA scenario and the higher in the AML scenario.

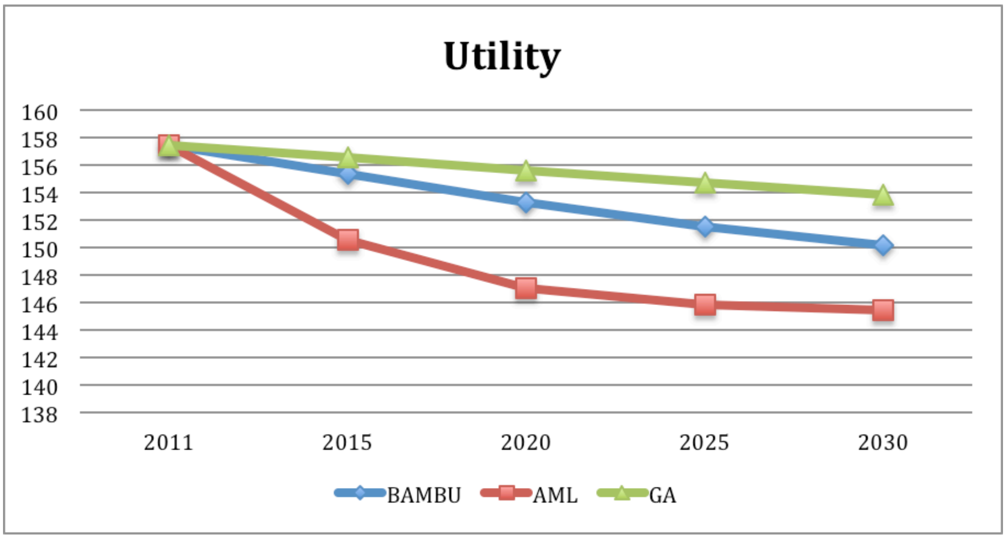


Figure 4 – Utility bring by the consumption of food (in 100 euros) from 2011 to 2030 in the BAMBU (blue curve), AML (red curve) and GA (green curve) scenarios.

4 Discussion and conclusion

In this paper, we propose a framework to analyse the economic contribution of insect pollinators at a local scale economy and their impact on the social welfare (SW). The novelty of this work is that social welfare is measured as the sum of farm's profit and consumer's utilities. Indeed, recent papers on the economic valuation of insect pollinator contribution have estimated it solely in focusing in one component of the welfare: supply side or consumption side. There are several papers that estimated the contribution of these insects at the supply side. This type of assessment has also been done at national and larger scales (France - Borneck & Bricout, 1984; Hungary - Benedek 1983; Switzerland - Fluri & Frick 2005; United Kingdom - Carreck & Williams 1998; USA - Robinson *et al*. 1989, Morse & Calderone 2000, Losey & Vaughan 2006; 12-member-states European Community - Borneck & Merle 1989, World – Costanza et al. 1997; Gallai et al. 2009). However as Winfree et al. (2011) explain, these studies make an incomplete measured of the pollinator contribution since they did not take into account production costs and adaptation costs to pollinator decline. In our paper we demonstrate that Winfree et al. (2011) are right but they omit to considers consumers. Some papers consider the contribution of insect pollination in the consumer welfare (for example Southwick and Southwick 1992 ; Gallai et al. 2009), but they assume that suply is perfectly elastic which limit the analysis.

In addition, our paper demonstrates that the pollinator contribution in the social welfare varies following, firstly the pollinator availability and secondly the substituability of food. Then the measure of the pollinator impact in our society is the result of sevreral mechanism that take into account interaction between farmers that produce insect pollinated good, farmers that produce not insect pollinated good, consumers that have preferences on insect pollinated good.

We modelized a local economy composed of an agricultural sector and a non agricultural one. The agricultural sector is composed of an insect dependent pollinator subector and a non insect dependent one. Then we observed the impact of an insect pollinator decline in this local economy in different scenarios. The intensity of the pollinator decline and the consequence in the social welfare vary following the political strategy of each scenario.

The scenarios describe an increase of consumer's revenues what leads to increase the consumers ability to consume food. Consequently the profit of firms increase all the scenarios. However the increase of profits are limited due to pollinator loss. We found that the better profit come from the GA scenario where pollinator loss is small. This result is particularly interesting since it describes higher cost of inputs compare to the other scenarios. The AML scenario that is described as the liberal scenario suffer to a very high pollinator loss. Consequently consumers will substitute insect pollinated food by food that does not depend on pollinators. This benefit to non dependent on insect subsector that would make more profit than the other subsector.

The consequence in terms of social welfare is double: firstly the gains in profit of firms are lower compare to the case of a non pollinator decline and, secondly, the decrease of the supply of pollinated food leads to a decrease of consumer welfare. However the consumer welfare loss is reduced due to the substitution possibility with non insect dependent food.

This model has been done in order to better estimate the consequences of an insect pollinator decline on our society. Thus it needs more realistics data than the one presented here. A future perspective would be to improve the quality of data collection. One solution could be the used of econometrics but it needs a detail database of a local economy. A more appropriate solution could be to interviews directly actors (farmers and consumers) of the local community. The model could be simplified by rendering prices exogeneous. In this way, the evolution of price could also be predict depending on the different policy scenarios.

Improvement of the model should include two more components within the welfare analysis:

- The specificity of the agricultural sector, which is food necessity *i.e.* a necessisty good that is difficult to substitute, and
- that one cannot substitute a good for which one has strong preferences i.e. a good for which one has anchoring of preferences (Tversky and Kahneman 1974; O'Connor et al. 1999).

Necessity goods are goods that we can't live without and won't likely cut back on even when times are tough (Hunter 1991). Food is a perfect illustration of a necessity good since we cannot live without it. However the amount consumed of this special good is limited to a certain quantity of calories per day (Malassis 2006). The economic theory defines this specificity as the Engel's law: the proportion of income spent on food decreases as income increases, other factors remaining constant. This law does not suggest that money spent on food falls with increase in income, but instead that the percentage of income spent on food rises slower than the percentage increase in income. This characteristic of food give to the agricultural sector a relative importance. This is why it is interesting to make the difference between the food sector and the non-food sector when considering the pollination service to agricultural production. However within the large set of food available, only a part depends on insect pollination. So even if food is not substitutable by non food goods, inside the food set, foods are substitutable in order to attain the goal of calories per day. Thus after a pollinator decline, we can assume that people would substitute the crops that are to expensive or no more available by crops that do not depends on pollinators.

Yet this not means that people will do it when taking into account the anchoring effects of preferences. Following Tversky and Kahneman (1974), the anchoring effect appear when people's decisions/actions are anchored to a certain vision of things. The subject will not move a lot from his point of view. During a lemon car' negotiation, if the price is not known by the buyer, the latter will negotiate in function of the price given by the sellers, even if the real price is lower since it is the only information available. This would leads to an inefficient equilibrium while it seems a rational behavior. Adapted to our case, the anchoring effect on preferences would lead the food consumers that are strong preferences on insect pollinator crops to keep going to consume strawberries even after a large price increase of the fruit due to a pollinator decline.

5 References

Agreste, 2013. http://agreste.agriculture.gouv.fr, last accessed March 2013.

Bauer, D, Wing I, 2012. The Macroeconomic Cost of Catastrophic Pollinator Declines, Ecological Economics, In Press

Benedek, P. 1983. Economic importance of honey bee pollination of props at the national level of Hungary. 29th International Apiculture Congress: Apimondia, 286-289.

Borneck, R., Bricout, J.P. 1984. Evaluation de l'incidence économique de l'entomofaune pollinisatrice en agriculture. Bulletin technique apicole 11(2), 117-124.

Borneck, R., Merle, B. 1989. Attempted evaluation of the economic worth of bee pollinators in european agriculture. Belgique Apicole 53, 210-215.

Carreck, N., Williams, I. 1998. The economic value of bees in the UK. Bee World 79, 115-123.

Biesmeijer, J. C., Roberts, S. P. M., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., Schaffers, A. P., Potts, S. G., Kleukers, R., Thomas, C. D., Settele, J., Kunin, W.E., 2006. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. Science 313, 251-353.

Brittain, C., Potts, S.G., 2011. The potential impacts of insecticides on the life-history traits of bees and the consequences for pollination. *Basic and Applied Ecology, 12*, *321–331*.

Costanza, R., Daly, H., 1992. Natural capital and sustainable development. Conservation Biology 6, 37–46.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, G.R., Sutton, P., van der Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

Daily, G.C., 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, DC.

De Groot, R.S., 1987. Environmental functions as a unifying concept for ecology and economics. The Environmentalist 7 (2), 105-109.

Ehrlich, P.R., Ehrlich, A.H., 1981. Extinction: the causes and consequences of the disappearance of species. Random House, New York

Eurostat, 2013. http://epp.eurostat.ec.europa.eu, last eccessed March 2013

Fisher, B, Turner, R.K, Morling, P, 2009. Defining and classifying ecosystem services for decision making. Ecological Economics, 68, 643-653

Fluri, P., Frick, R. 2005. Beekeeping in Switzerland: state and perspectives. Revue Suisse d'Agriculture 37(2), 81-86.

Gallai, N., Salles, J. M., Settele, J., Vaissière, B. E., 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics 68, 810-821.

Gallai N, Figuières C, Salles JM, Vaissières B, 2009. Welfare incidence of an ecological shock in a general equilibrium setting, working paper LAMETA , University of Montpellier, Montpellier DR-2009 17.

Gallai, N., Vaissière, B. E.. 2009. Guidelines for the economic valuation of pollination services at a national scale, FAO publication, Roma p. 26. Available at http://www.internationalpollinatorsinitiative.org/uploads/POLL%20VALUE%20NATIONAL%20MANUAL.pdf

Gómez-Baggethun, E, De Groot, R.S, Lomas, P.L, Montes, C, 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecological Economics, 69, 6, 1209-1218.

Hunter, L., 1991. The contribution of nonhomothetic preferences to trade. Journal of International Economics, 30(3–4), 345–358. doi:http://dx.doi.org/10.1016/0022-1996(91)90027-4

Klein, A. M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunnigham, S. A., Kremen, C., Tscharntke, T., 2007. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society 274, 303–313.

Levin, M. D., 1984. Value of bee pollination to United State agriculture. American Bee Journal, 184-186

Losey, J. E., Vaughan, M., 2006. The economic value of ecological services provided by insects. BioScience 56, 311-323.

Malassis, L., 2006. Ils vous nourriront tous les paysans du monde, si ..., Ed. Quae, Montpellier, Paris, Centre de coopération internationale en recherche agronomique pour le développement Institut national de la recherche agronomique, 460 p.

Millenium Ecosystem Assessment, 2005. Ecosystems and human well being: a framework for assessment. Report of the conceptuel framework working group of the Millenium Ecosystem Assessment. Washington, DC.

Mendelsohn R, Nordhaus W, Shw D, 1994. The impact of global warming on agriculture: a Ricardian analysis. American Economic Review, 84, 4, pp753-771

Morse, R. A., Calderone, N. W. 2000. The value of honey bees as pollinators of U.S. crops in 2000. Bee Culture, 1-15.

O'Connor R, Johansson M, Johansson PO, 1999. Stated preferences, real behaviour and anchoring: some empirical evidence, Environmental and Resource Economics, 13, 235-248.

Perrings, C., Folke, C., Mäler, K.G., 1992. The ecology and economics of biodiversity loss: the research agenda. Ambio 21, 201–211.

Ricketts, T. H., Daily, G. C., Ehrlich, P. R., Michener, C. D., 2004. Economic value of tropical forest to coffee production. Proceedings of the National Academy of Sciences of the United States of America 101, 12579-12582.

Southwick, E. E., Southwick, L., 1992. Estimating the economic value of honey bees (Hymenoptera, Apidae) as agricultural pollinators in the United States. Journal of Economic Entomology 85, 621-633.

Sukhdev, P., Kumar, P., 2010. The Economics of Ecosystems & Biodiversity (TEEB). *Available at:* http://ec.europa.eu/environment/nature/biodiversity/economics/pdf/teeb_report.pdf.

Tversky, A. and D. Kahneman (1974), Judgment under uncertainty: heuristics and biases, Science, 185(4157), 1124-1131.

Westman, W., 1977. How much are nature's services worth? Science 197, 960–964.