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RESEARCH IN ECONOMICS AND RURAL SOCIOLOGY

Economic analyses of biodiversity: Assessment of stakes and modelling of policies

Should we worry about the erosion of biodiversity? What can be done? Several studies carried out within the joint research unit LAMETA present biodiversity as a rather complex notion, the value of which does not accurately appear on any market. However, the partial assessments that can be made through other means show its importance, but its preservation is no easy thing. Since biodiversity greatly concerns private properties and also sovereign States for which the protection of the nature is not (yet) a priority, the statutory approaches are of limited help. We must try to gain a better understanding of the social forces that compromise biodiversity and use these same forces to preserve it.

Research stakes and objectives

Biodiversity is an important dimension of life. It contributes to its dynamics, while increasing its capacities to offer a set of services, as much productive and recreational as cultural or spiritual. Despite major difficulties of measurement, this acknowledgement is now widely shared: Biodiversity is threatened by human activities under the combined effects of the conversion of natural areas, pollution, climate change and the problem of invasive species, the spreading of which is made easier by the development of long distance exchanges.

The neologism biodiversity appeared in the middle of the 1980s but like the controversies it created, the related problems date back long before. The scientific or political definitions of biodiversity underline its more or less structured complexity: inter-specific diversity (the easiest to characterize, but not necessarily the most significant), intra-specific and ecosystemic diversities. For economic analysis, the problem is, above all, that of the measurement of the value of biodiversity: do the present dynamics and their negative impacts on the services provided by ecosystems, or on the deterioration of patrimonial elements constitute serious threats to our societies and do they justify more ambitious and costlier specific policies?

For some ten years, a lot of research works have been carried out within the joint unit LAMETA to clarify and highlight these problems and study the solutions that could be brought by public policies. We shall present them following a twofold rationale: understand and assess the extent of the problems (section 2); and analyse and model the effects of some international and national policy tools able to remedy them (section 3).

Deterioration of biodiversity: is it serious?

A first level of analysis obviously concerns the framework that helps define and, if possible, measure diversity.

Numerous proposals of concepts, indices or measures have been made by ecologists and economists. None of these criteria answers all the questions raised by biodiversity.¹

Be that as it may, the social justification of a specific conservation effort refers to the question of the value of biodiversity,² in a fairly broad framework which, of course, mobilizes ethical considerations (right to life, freedom of choice...) but also practical ones (socially satisfactory alternatives, potentialities, reliability and robustness of analyses and measurements). The value of biodiversity must then be compared with the cost of conservation. The LAMETA joint unit developed more specific research on the assessment of the biodiversity services provided to agricultural production through its participation in two programmes: the assessment of pollination for agriculture and value of diversity in the landscapes.

Assessment of the vulnerability of agriculture compared with the decline in pollinating insects

For those concerned by ecosystem services, the decline in pollinating insects has become an increasing concern. What is its impact? The value of the pollinating service to agriculture has been the subject of various studies at different geographic scales.

In a recent work (Gallai et al., 2008), we suggest an assessment of this value at the world scale. A review of the literature helped calculate a ratio of dependency towards some insects for each of the ten crops contributing to human food. Using FAO data, it is possible to calculate the volume, then

¹ An overall presentation of the properties of these various measures is proposed in another paper of this publication: Figuières C., Assessment criteria of biodiversity: properties and difficulty of use

² During the last years, the question of ecosystemic services and biodiversity has given rise to multiple institutional and political initiatives and in particular to a collective assessment by INRA (2008) on agriculture-biodiversity relationships and a report on the monetarisation of biodiversity and the assessment of ecosystemic services from the French Centre of Strategic Analysis (2008).

the value of the loss of the crops that a global decline in the pollinating service would entail. The global value of the pollinating service was established at 153 billion euros. Related to global production value, this represents 9.5% in 2005, which may be expressed as a *ratio of vulnerability* of the world food base.

Three categories of crops (according to the FAO definition) are mainly concerned: fruit and vegetables are the most affected, with an annual loss assessed at 50 billion euros each, followed by oilseeds with 39 billion; the impact on stimulants (coffee, cocoa, tea), nuts and spices would not be so high. These calculations helped show that the average value of the crops depending on pollinators was quite higher (761€ per ton) compared to that of the non dependant crops (151€ per ton). It is clear that for fruit, vegetables and stimulants, food balances would be deeply modified, in particular in regions like the European Union.³

We calculated from a simple model the losses in social welfare that would be generated by a complete decline in pollinators.⁴ For two possible scenarios on the reaction in terms of consumption resulting from higher prices, we obtain a world welfare loss varying from 190 to 310 billion Euros annually, which represents between 0.7 and 1.2% of world GDP.

These stakes are obviously major but probably less catastrophic than some alarmist discourse is implying. However, these figures only concern the crops directly involved in human food. If the adaptation strategies of certain economic actors are likely to limit the consequences of the decline in pollinators (land reallocation, resorting to substitutes in the agrifood chains), it would be, moreover, necessary to add its impact on cattle-breeding, on other non-food crops and maybe in a more worrying way, on wild flora and, then, the ecosystemic services provided to agriculture and to the rest of society.

Landscape and biodiversity: what are the interactions? A study of the Anciens Marais des Baux-de-Provence (dried marshes of the Beaux de Provence)

The Millennium ecosystem Assessment underlined the importance of the services rendered to humanity by the ecosystems, adding a functional and utilitarian dimension to the patrimonial dimension of biodiversity. But introducing this new dimension into the biodiversity agenda has aroused debate and numerous studies have underlined that biodiversity could also produce pollution or negative effects⁵ that the cost-benefit analysis had to take into account in the assessment of restoration or conservation projects.

In a pilot study on the restoration of a wetland on the Anciens Marais des Baux dried marshes site (Provence), we used the

contingent choices method to assess the interactions in inhabitants' choices between the intensity of restoration of the wetlands, potentially providing an increase in biodiversity and associated pollution, in particular through the proliferation of mosquitoes (Lifran and Westerberg, 2008). The method of payment suggested is residence tax for residents and tourist tax for tourists.

In this context, the inhabitants' choices are highly influenced by the option offered by the manager of control over this pollution, which conditions the level of willingness-to-pay in return. For example, it seems that their average willingness-to-pay for an intermediate level of biodiversity is 18 euros per year, almost three times more than the 7 euros/year for a high risk of biodiversity, which would be associated with greater pollution due to mosquitoes. Another example, pesticide control, is negatively assessed while the control of mosquitoes by natural means, such as management of the water levels, is valued at 20 euros. Therefore, a larger restoration of the marshes combined with a natural control of mosquitoes, takes the willingness-to-pay up to 31 euros for this scenario. In the same way, one of the dimensions of the project, the restoration of hedges, introduces competition between the increase in biodiversity and the wish to keep a view of the Alpilles.

The econometric method used, "choice modelling", takes into account the diversity of the preferences expressed in the survey and relates them to the personal characteristics of the respondents. This is how the method not only offers decision-makers an aggregate value of the social benefits linked to the project, but also clearly specifies its outlines in order to better manage the dialogue and negotiation stage of the definitive project, which increases its acceptability.

Beyond these two examples, it is clear that it is difficult to characterize the problems and specify their impact. The irreversible nature of certain deteriorations, however, constitutes a strong motivation to implement or accentuate specific policies.

Analysis and modelling of policy tools

The policy tools of conservation integrate the fact that biodiversity is widely located on lands with private status and that, in highly protected zones, it is a matter of controlling its use but more generally of encouraging agents to adopt behaviours more favourable to conservation on a voluntary basis, that is to say most often to commit themselves contractually with public agencies.

Of course, farmers and forest owners (through their farming practices and their choice of space development and management) are the first people concerned by the public policies on biodiversity conservation. But integrating this objective into the CAP is no easy thing: the agriculture-biodiversity collective assessment dedicates a chapter to the articulation between agricultural and environmental policies and shows that the latent opposition between the two is likely to change under the pressure of new stakes, which, for farmers, are incentives to consider biodiversity as an asset rather than like an obstacle in the context of new agro-ecosystems. The problem of incentives for biodiversity conservation must be tackled both at the scale of farms and at that of the global socio-economic context.

³ However, we must underline that our approach is not a prediction, since a whole host of strategic answers, as much at the level of the producers as that of the agrifood chains, were not taken into account.

⁴ At this level, in the model used to carry out the coherent practical calculations until the end, farmers were supposed to sell at cost-price (which was realistic on 2005 data, but is more debatable at current prices) and then the social surplus variations are assimilated to the consumers' surplus losses.

⁵ This question of associated pollution has been quite well studied in the case of populations of protected species inducing pollution. It has been more rarely studied at the level of the habitats or ecosystems.

Biodiversity policies and incentive mechanisms

A first observation concerns the diversity of forms that the incentive measures take, as well as the public actors who implement them (Rulleau and Salles, 2003). Beyond the obvious historical sedimentation, this plurality must be related to the heterogeneity of biodiversity components and their status, which involves various actors and forms of intervention.

Managing biodiversity in a contractual framework

Contracts offer a whole set of possibilities for public agencies in charge of biodiversity conservation.⁶ But they also present a handicap: as incentive tools, they obviously present no guarantee as regards spatial continuity (which may be ecologically necessary). This observation has led to a theoretical exploration of contract performance in complete information, relying on the combination of a payment based on individual effort with a payment based on collective performance. This type of contract has a twofold objective: encourage farmers to adopt technologies with a lesser impact and increase their remuneration if these eco-techniques are also applied to adjacent areas (Krawczyk et al., 2005). When the available budget is limited, the model shows a higher efficiency of the coupled incentives than the individual incentives.

An analysis of the evolution of the objectives and forms of actions of the Cévennes National Park (NPC) in favour of nature, then of biodiversity (Chassany et al. 2004) shows that in the four fields i) of protected species, ecosystems and landscapes, ii) of hunting management, iii) of forest management and iv) of agriculture and cattle farming, we may observe a similar development of regulation action towards incentive and contractual measures. These observations express, on the one hand, the significance of the highly protected zones as a territory for learning management of society-nature relationships, and on the other hand, the increasing importance of the incentive approach, as much to counterbalance the State's loss of legitimacy as to improve the efficiency of the action of a territorialized structure having to reconcile the conservation and development objectives in its relationships with residents.

An assessment of the NPC strategy as regards agro-environmental formalization by contracts showed, on the one hand, the development of the establishment's objectives and the recent strategic refocusing on biodiversity, and on the other hand, the supplanting effect of measures such as the CAP agro-environmental grazing allowance towards more ambitious and more restrictive contracts, but insufficiently granted or sustainable to be really attractive to farmers.

To draw up efficient contracts - both from a budgetary point of view, by avoiding over-compensation of farmers for their implementation costs, and from an allowance viewpoint by focusing on the farmers who are able to produce the best gain in biodiversity at the lowest cost to society - we have to overcome the asymmetries of information between the regulator and contractors. We analysed the advantages and limits of an allocation of conservation contracts (and of agro-

environmental contracts) by an auction system (Thoyer and Said, 2007) with farmers competing both on their biodiversity offer and on the amount of the allowance. We show that such mechanisms may help run better the synergy effects between several measures (Said and Thoyer, 2007), but that they are often in tacit competition with other agricultural policy objectives, in particular income support.

Biodiversity as a joint product in agriculture

To study the behaviour of risk-averse farmers in the face of the production of an environmental good such as biodiversity, a theoretical framework allows least intuitive stakes to be explored. The research following P. Havlik's thesis (Havlik & al., 2005; Havlik & al., 2008) considers agro-environmental measures to be a no-risk activity for a cattle producer in a situation of price uncertainty. It shows that adopting a favourable measure for biodiversity, but to the detriment of cattle production, leads to an intensification of the latter. They also show that an increase in the variability of output prices or a fall in the level of decoupled aid will have a positive effect on the number of hectares dedicated to biodiversity in tacit competition with cattle production; but the effect will be negative if this biodiversity is complementary to the cattle production.

Practical successes based on convergence of interests

Contractual policy sometimes enjoys real successes such as in the case of the concerted local development plan (CLDP) for the Méjan⁷ (in the Lozère department in France) which may be explained by a convergence of interests between cattle breeders wishing to prepare for the drop in public support to production by coming back to a more systematic use of spontaneous fodder resources and the willingness to preserve the open landscape of the "bare Causse" (limestone plateau in the South-Centre in France). The partners (cattle breeders, foresters, CRPF (regional centre for forest property), NPC, INRA) meet and define a strategy which will be contractually supported by the CLDP financed by the Languedoc-Roussillon region and the European Union (Chassany and Salles, 2008). However, the exceptional nature of this case leads us to wonder whether, in practice, the efficiency of contractual mechanisms requires an improbable convergence of interests.

It is not an isolated matter. The case of the GeLoSe (Secured local management in Madagascar) which consists in entrusting basic local communities with sustainable management and promotion of some resources contained within the boundaries of their region, seems to lead to similar conclusions (Antona et al., 2004).

The economic literature has defined the context in which it is rational for an agency to delegate the management rights to an asset:⁸ put simply, entrusting real authority is pertinent if the entities who receive it get better information on the specificities of the asset to be managed and if the objectives of

⁶ 3rd BioEcon Workshop, *Contract mechanisms for biodiversity conservation*, Montpellier, May 23-25, 2003, (http://www.bioecon.ucl.ac.uk/09past_3.htm)

⁷ Etienne M. & Le Page C. (2008). Modéliser les dynamiques paysagères pour accompagner un projet d'aménagement du territoire : le cas du Causse Méjean. in Chassany J.-P. & Crosnier C. , eds., *Les Grands Causse, Terres de patrimoine, Terres d'expériences* (sous presse).

⁸ Aghion, P. and J. Tirole (1997), 'Formal and real authority in organizations', *Journal of Political Economy* **105**: 1-29.

these entities are not in contradiction with those of the authority which holds the formal rights. Could the enthusiasm of the NGO and the international development agencies in favour of decentralisation of managing resources towards local communities be explained by this theoretical result?

Obviously, their motivations are wider-reaching and exceed just economic efficiency, but our analyses of contracts for the delegation of management rights in the case of the GeLoSe show the essential role of the “mediators” whose function is precisely to have created convergence between the objectives and concrete processes of the parties (the village communities and the water and forest administration) who initially only perceive their antagonisms.

What effect can be expected from North-South financial transfers?

Before 1992, biodiversity was seen as a shared heritage of humanity. The introduction of competition for this notion with the legal frameworks intended to manage the innovation stakes linked to biotechnologies, led to the affirmation in the founding articles of the Convention on the Biological Diversity (signed in Rio in 1992) of the principle of the States’ sovereignty over their genetic resources. Even though this sovereignty goes with some responsibilities, the international community has coordinated its actions better to preserve biodiversity the most efficiently possible, where it is the most plentiful and the most threatened, most of the time in developing countries. The international North-South transfers may be incentives to increase their conservation efforts. Two questions are asked: How to divide the conservation costs within the international community? May the transfers not directly linked to biodiversity concerns have an impact on conservation efforts and why?

International negotiations and level of protection of biodiversity in the South

A first objective was to analyse the conditions and the end of the negotiations on the level of biodiversity protection in the context of a simple model with two groups of countries, the North and South (Aulong et al., 2005).

In a stylised way, the South has the potential for biodiversity conservation, while the North enjoys this biodiversity without being able to produce it. At status quo, an increase in conservation efforts harms the short-term interests of the South while the developing countries and the whole world would benefit from them. The negotiation problem is the following: how to organize the compensatory transfers of the conservation-protection costs to be implemented from developed countries towards developing ones in order to produce an optimal level of biodiversity, given that 1) each of the developed countries is likely to behave as a “free rider” and let the other countries contribute; 2) There is no supranational authority which has the necessary information on the countries’ willingness-to-pay for biodiversity and which has the power to implement a socially efficient rule of transfer?

The approach consisted of updating the properties of a negotiation scheme in which the funding level requires a majority vote. In this context, we show that voting honestly is a dominant strategy for each developed country, thereby

settling the incentive question, but the constraint of the individual rationality is no longer verified (some countries may lose out in the negotiation). However, this process converges on a Pareto optimum under the rather restrictive requirement that the median of marginal net benefits becomes identified with their average. Otherwise the process may end up on a second-best optimum. Furthermore, an extension of this work shows that when countries may be excluded from conservation benefits (for the “public good with possible exclusion” dimensions of biodiversity), such a process always leads to a second-best optimum, but this time individual rationality is respected.

Impact of international lump transfers on arbitrages between agricultural production and biodiversity protection

Conditional transfers (paid according to the efforts made by the receiving countries) represent marginal sums compared with the transfers linked to development aid and to direct investments abroad. To what extent can these lump transfers change the structure of consumption and production of countries and ensure arbitrages progress on the use of the natural capital in the South? We developed a theoretical simplified framework, close to the model previously presented, which more clearly represents the competition between biodiversity protection and the development of agricultural production (Aulong et al. 2006). When only the dimension of the global public good of biodiversity is taken into account, the development aid of the Southern countries does not modify the countries’ overall contribution to the conservation effort. But some cross-border ecosystems (forests, wetlands and so on) offer environmental and recreational services which may be considered as public inputs entering without rivalry or exclusion into the production function of the Southern countries. We show that international transfers may improve global welfare even in situations in which their effect is to reduce the global level of biodiversity. In an analytical way and in the case of natural areas, we also find some support to the Kuznets environmental curve, which shows that, statistically, the environment tends to deteriorate as the country’s income increases, until a return point beyond which conversely the increase in incomes goes with an improvement in environmental quality. Moreover, econometric analyses are in progress to measure the marginal impact of international transfers on the conservation efforts in the South (measured on the one hand by deforestation and on the other hand by the surface of protected areas).

Conclusion

All these studies, disparate at first sight, contribute to a cumulative knowledge of biodiversity. They show a strategy of progressive rebuilding of a puzzle from points of view or models which, each in its own way, contributes to a better understanding of the subject. In its special perspective, every piece of the puzzle reduces ignorance and ideally contributes to a more and more substantial and operational general description.

As regards the economics of biodiversity, this process is still at its beginnings. Biodiversity appears like a rather complex notion. For these reasons and for some others, its value cannot yet correctly reveal itself on markets. However, the partial assessments that can be made through other means show its importance (even if in the imagination of some, this value may

have been exaggerated) and, with the usual precautions, justify the attention that is paid to it. That said, biodiversity protection is far from being an easy thing. Because biodiversity potential is mainly located in private properties, and also in sovereign States for which nature protection is not yet a priority, the regulatory approaches are of limited help. We must try hard to understand the social forces which compromise biodiversity and use these same strengths to preserve it. As a minimum, this leads us to reconsider the

robustness of the usual incentive tools and probably imagine new ones.

To conclude, it may be a paradox to think in terms of optimal allocation of means or efficiency of conservation policies for an asset for which the questions of measures are far from being clarified. It is probably the essence of the research to take badly signposted paths. But this does not prevent us from thinking, in a concomitant way, about biodiversity indicators, and beyond, about the meaning of things.

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