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"Viability", an approach to sustainable development aiming to avoid crises over time: the case of fisheries

Nowadays, sustainable development is an explicit objective of all policies; it aims to reconcile economic, environmental and social issues, as part of a concern for intergenerational equity. The "viability" approach takes into account a set of sustainability stakes in a multicriteria dynamic framework. This approach is complementary to the classical ones based on the optimization of one sole criterion (for example, economic). It defines the configurations of sustainable exploitation of an ecological and economic system and explores the decisions to avoid or exit an over-exploitation crisis. We illustrate this approach with the results obtained in the case of fisheries management.

Sustainability: a new challenge

One of the challenges of economics is to study the ways of using rare resource stocks and by extension, to define optimal use of these resource stocks in order to help agents to choose between various possible uses. The optimization criteria are economic, for example inter-temporal discounted profit. Therefore, the (economically) optimal exploitation of fish stock will be that which will maximize fishermen's incomes.

But the issues of sustainable development as it is displayed today, an objective of public decision-making, are inherently multidimensional, both at the local and global levels. We must reconcile economic, environmental and social issues. In the case of fisheries, it is vital to protect fish stocks and employment in fisheries while ensuring economic profits. The economic approach alone is not sufficient any more, and an interdisciplinary and multi-criteria approach has become necessary.

To borrow the terms of the Brundtland commission report (1987), "sustainable development must meet the needs of the present generations without compromising the capacity of the future generation to satisfy their own needs". Therefore, the present decisions should aim at different and sometimes contradictory objectives, in a context of intergenerational equity. The viability approach tackles such an issue in a multicriteria framework. This approach is not based on the optimization of an economic criterion but on the definition of a set of constraints, representing the different objectives of sustainability to be observed in each period in order to avoid a *crisis* in the system.

Over-exploitation of natural resources: a dynamic problem

The exploitation of natural resources results from the interaction of the natural dynamic of the resource and the economic dynamic of the exploiting sector. If the extraction of resources exceeds the stock restoration capacity over a prolonged time, the resource may quickly become overexploited and face a risk of extinction. This is the case of the marine fish resources and fishery management for which extensive research work shows that most of the renewable marine stocks are fully exploited or overexploited. The sustainability of their exploitation has become a central concern. The main objectives of fishery management are:

- The sustainability of resource exploitation, so that fish stocks and the workings of the ecosystem are preserved,
- The economic profitability of the resource which must enhance the value of use of resources,
- Protection of jobs in the industry and maintenance of the associated communities or ways of life.

These are multidimensional objectives and, in the long run, fishery sustainability will rely on the achievement of all these objectives, taking into account ecological and economic dynamics.

Multiple sustainability objectives and decisional stakes

Some of the objectives to be achieved may run counter to each other. In this respect it is difficult to determine the decisions which will have a simultaneous positive effect on all the objectives, and the decision-maker will often have to arbitrate between these objectives. In the case of a fishery, arbitrating in favour of employment will often be done at the expense of economic profitability or stock durability.

For the regulator, the main issue is to integrate all the objectives of sustainable development in the decision in order to avoid crises. Rather than a rule of optimum management favouring one sole objective, management rules must be defined with a view to reaching all the objectives at the same time. Within such a framework, researchers may, on the one hand indicate the various management options and their implications and on the other hand, describe the set of objectives that can be reached, as well as the arbitrage required between these objectives. The "viability" approach provides tools in both cases.

The viability approach

The viability approach helps to tackle the issue of sustainable development by representing the sustainability objectives by a set of constraints. These constraints can include a number of indicators to be above thresholds: minimum stock of fish, employment, profits… In the case of the Bay of Biscay Nephrops fishery (Martinet *et al.*, 2007 and 2010), we considered the "fishery stock" dynamic system as sustainable if:

- The resource stock is kept above a threshold (usually determined by ecologists): this is a biological objective;
- The fleet vessels have a profitable economic activity: this is an economic objective;
- The fleet keeps a minimum size to help maintain employment in the area and guarantee an income to local populations: these are social objectives.

If some of the objectives are not fulfilled, the fishery will face a crisis which may be biological, economic or social.

By trying to define how to respect all the viability constraints over time in order to fulfil all the sustainability objectives, the viability approach no longer defines an optimum use of resources (optimum in respect of this criterion) but all the viable uses of the resource, viability being defined as the satisfaction of all the objectives, whatever their dimension (economic, ecological or social).

The second key point of the approach is that viability focuses not on the objectives to be achieved at a given time, but dynamically. In order for stock exploitation to be sustainable, viability constraints must be satisfied at all times and not only in the short term, and must therefore take into account the stake of intergenerational equity. The possibility of reaching the determined objectives in the future depends on the present choices. These must not only satisfy constraints for the present generations but also lead the system towards a future state which will again bring the satisfaction of these constraints. We then attempt to anticipate the trajectories of dynamic systems and define the states and decisions which allow the satisfaction of the viability constraints over time.

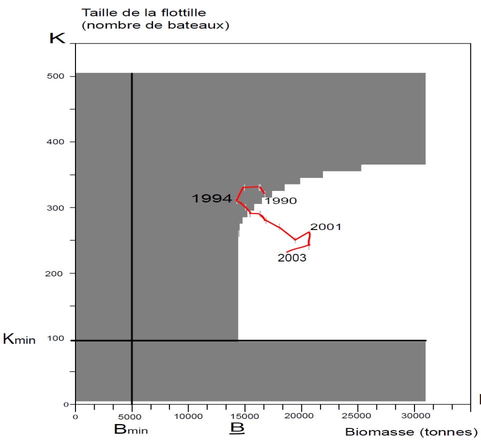

Figure 1: Viability of fisheries

In the fishery example, we have to define the states of the stock of resources and the fleet size as well as the decisions governing exploitation and adjustment of the fleet which are compatible with the set of objectives.[1] These states are represented in Figure 1 by each of the points of the white zone. From each of these states, it is possible to define a "viable" fishery exploitation trajectory, that is to say, one which satisfies the constraints in every period. Conversely, if the system starts from a "vessel number - fish stock" pair located in the grey area, one or more viability constraints will inevitably be violated in a finite time and irrespective of the decisions taken. Even if these objectives can possibly be reached in the short run, it is impossible from these states of the system to achieve our objectives on the long run, and at one moment or another, the system will inevitably face a crisis. This is the case when the fleet size is too high compared with the resource stock and capital inertia makes it impossible to reduce the vessel number fast enough. The system will face either a biological crisis if the exploitation carries on preserving a viable profit for the fishery, or an economic crisis if extractions are reduced by limiting the vessels' efforts at an economically unviable level to preserve the resource stock. Keeping the system within the set of viable configurations represents the true management target of our system. If this target proves to be more restrictive than satisfying the constraints at a given time, however, it is definitely the one which satisfies these very constraints in the future (see Martinet and Doyen, 2007).

[1] From a methodological point of view, we may define whether a state is viable by minimizing a criterion which adds together, along a trajectory, the number of periods for which one or more constraints are not satisfied. If there is a viable trajectory, the criterion is worth zero and the starting state is viable. Technically, to define a viability kernel, we use a Bellman equation which resolves problems of dynamic optimization. This helps to define the value function of the viability problem. All the states for which the value function is nil are within the viability kernel.

Figure 1 also shows the historical trajectory of the fishery. We see that it faced a crisis during the 1990s, the trajectory being outside the viable states during those years. Next comes the issue of the recovery from crisis situations.

Times of crisis and recovery paths of systems

Like our fishery, many natural resources are already overexploited and need regeneration process systems to be defined beyond processes of their sustainable uses. The viability framework may be extended in order to examine the recovery strategies to get over these economic, social and/or environmental crises. The crisis time of a trajectory of exploitation corresponds to the global period during which the system is faced with a crisis regarding one or several objectives. We note that from this point of view, a viable trajectory has a null time of crisis and that it corresponds to a development aiming to avoid crises on the long run. When crises are unavoidable, minimizing crisis time amounts to minimizing the periods where sustainability objectives are not reached (transition time towards viability kernel). Figure 2 presents the minimum time of crisis associated with every state of the fishery studied (Martinet *et al.*, 2007). Every coloured area around the previously defined kernel of viability corresponds to the states of the system from which the fishery will, at best, face one, two, three (or even more) years of crisis. The further-off the fishery from viable configurations, the longer the crisis.

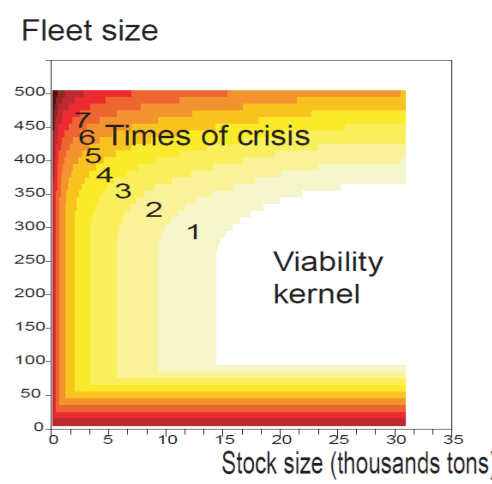

Figure 2: Time of crisis and economic compromises

The fastest strategy for the fishery to recover consists in shutting it down while the fish stock regenerates. This strategy minimizes the crisis time, but the loss of earnings for the fishermen may be considered socially unacceptable.

Acceptability of regeneration measures

Not all recovery measures are acceptable. The failure of restoration programmes for the systems in crisis often comes from not taking into account the individual costs of the measures suggested. The cost faced by the agents in charge of the resource may lead to non-application of the restoration measures. Therefore these measures must be socially acceptable. To assume this dimension of the problem, we must limit the set of potential decisions during the restoration phase, which means defining a minimum time of crisis under transitional constraints.

In our case study, the transitional constraint consists in guaranteeing a minimum annual profit for every fisherman. Although lower than the economically viable profit, this profit helps cope with some short-term costs (salaries, loan repayments, vessel maintenance costs and so on) and makes restoration measures more acceptable. However, such a concession increases the time required for the system to recover. It is possible to describe the arbitrations between “crisis time” and “social acceptability”. As a rule, as illustrated on figure 3 in the fishery case studied in Martinet *et al*. (2010), the higher the sacrifice required from the agents, the shorter the time of crisis.

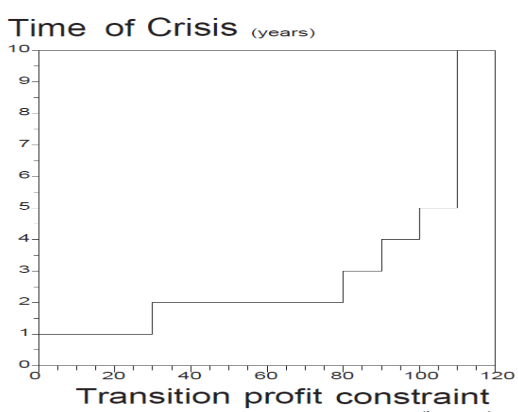

Figure 3: Time of crisis and annual profit guaranteed during regeneration phase

If we wish to guarantee too high a profit during the recovery phase, the time of crisis may even become indefinite (asymptote on the right side of the figure beyond the transitional profit of 110,000 €/year).

Trade-offs between objectives

Another essential angle of the sustainability issue lies in the way in which the objectives to be reached are defined (that is, the level of viability constraints).

The viability analysis of a system helps determine the objectives that may be reachable from the initial state of the ecological-economic system. It is conceivable that a higher ecological objective may be reached (respectively, economic) than the one that was initially fixed if we accept to revise the objective of economic viability downwards (respectively, ecological). We can describe the set of possible trade-offs between objectives of various types, and the substitution level between these objectives. This is what Martinet and Blanchard (2009) describe about a fishery and an objective to preserve sea-bird species.

The description of the set of sustainability objectives that may be reached provides the regulator with a clear view of the conceivable trade-offs. It may, thus, be desirable to redefine the level of the sustainable objectives in order for them to become reachable (and for decisions to achieve them to be taken) rather than follow objectives which, in any case, are not reachable in the long run (even if they may seem so, in the short term).

The viability approach is a multi-criterion approach which helps tackle all the dimensions of sustainable development in the same framework, without giving priority to any of the pillars. Moreover, it does not give priority to any generation in particular, viability constraints having to be satisfied in the same way at all times, in a perspective of intergenerational equity. Last, it makes explicit the trade-offs between various sustainable objectives and provides a decision-making tool favouring choice between those objectives.

Viability in agriculture

This approach is applicable and has started to be implemented in agricultural issues. Sustainable agriculture must (i) be profitable for producers, (ii) satisfy food demand, (iii) produce biomass with energy purposes, while (iv) preserving the environment, the natural habitats and their biodiversity. It would be interesting to describe the necessary trade-offs between these various objectives. For instance, the production of biofuels could require a reduction in the quantity of food production, intensifying production at the expense of the environment, or an extension of farmlands at the expense of biodiversity.

Moreover, the viability theory would help define the use land use and land-use change compatible with a given set of sustainable constraints. If the objectives set are not reachable in the present configuration of the agro-economic system, we shall try to define transitional paths to future agriculture, under the constraints of the social acceptability of change (for instance, production of a large quantity of biofuels while ensuring that increasing production does not jeopardize food safety).

Vincent Martinet,
INRA - Economie Publique, Grignon
vincent.martinet@grignon.inra.fr

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For further information

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