Sustainable development assessment and the management of heterogeneous fisheries activities: the case of European Union participation in Senegal’s marine fishery

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Abstract
The article introduces a methodology for evaluating the sustainable development consequences of the activities fishery groups frequenting Senegal’s marine fishery. A discussion of the conditions for sustainable development suggests that the sustainable development of fisheries is dependent upon complex interdependencies between heterogeneous factors. The interdependencies between these factors leads to the assumption that assessing the sustainable development status of fishery systems should rely upon descriptive multi-criterion assessments rather than the use of composite sustainability indices.

A descriptive multi criterion assessment method is developed and proposed as a means to evaluating the sustainable development consequences related to the activities of three user groups frequenting Senegal’s marine fishery. These groups are the local artisanal group, the local industrial group and the European Union distant water fleets which were present in Senegalese waters until June 2006. The assessment method is applied in an empirical analysis of the sustainable development impacts of the activities of each of these groups. The results of this evaluation show that the heterogeneity of the user groups frequenting Senegal’s marine fishery system can be capitalised upon through allocating fishery access in accord with each group’s ability to generate sustainable development benefits, while taking policy action to mitigate their negative impacts. On the basis of these findings the article suggests that the presence of an EU fleet in Senegalese waters could play a meaningful role in ensuring the sustainable development of Senegal’s marine fishery.
**Introduction**

In June 2006 the most recent protocol of the fisheries’ agreement between Senegal and the EU expired and was not renewed for the first time in 31 years. Spectators and commentators have suggested that this action is for the benefit of the sustainable usage of the resource by local fishing groups.¹ The extent to which the sustainable development of Senegal’s marine fishery will be enhanced through the non renewal of the long standing fishing agreement with the EU is the primary subject of this article.

We contextualise the uncertainly around the merit in the non renewal of the fishery protocol between Senegal and the EU as a symptom of a broader challenge related to sustainable development assessment. In addressing the primary research topic of the article we therefore first address the question of sustainable development assessment.

The article has two main parts. The first introduces a new methodology for sustainable development assessment, while the second applies this methodology to the case of Senegal’s marine fishery.

We begin with a description the concept of sustainable development and the perceived conditions for it. This is done with a view to developing the assessment method which is able to address the main characteristics of the concept.

The assessment method, Sustainable Development Directives (SDD), is then applied to the case of Senegal’s marine fishery. We use the descriptive multi-criterion methodology to evaluate the sustainable development consequences of the activities of three fishing groups frequenting Senegal’s marine fishery. Our evaluation leads to three policy recommendations which are intended to guide the fishery onto a sustainable development trajectory.

These recommendations are made within the parameters of the SDD methodology which views sustainable development assessment, and decision support, as an iterative process whereby incremental improvements in SDD assessments lead to more optimal policy outcomes from one iteration to the next.

**Sustainable development**

The concept of sustainable development has been described as development in which total welfare is non-decreasing over time, and where welfare is dependent upon the integrity of environmental capital, social capital and economic capital.² In practice a fourth form of capital, institutional capital, is viewed as a catalyst for ensuring that appropriate balances between the former three is achieved. The conditions for sustainable development therefore involve the preservation of appropriate balance between natural capital, social capital, economic capital and institutional capital.

Managing economic processes in accordance with sustainable development therefore requires that appropriate balances are maintained between these capital types. Attempts to provide management decision support in respect of this objective have encountered

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two primary obstacles. First, the interdependencies between capital types are stochastic, making their relationships in the sustainable development process non-linear. This makes it impossible to accurately explain and model the interactions between these factors. Second, the extent to which these capital types are substitutable in the production of sustainable economic development benefits is questionable. The reasons for this are well documented and transcend the scope of this discussion. ³

As a result of these two obstacles composite measures of sustainable development are unable to explain or accurately describe the sustainable development process or role played by the variables within it. The corollary of this is that composite measures are equally unable to explain the sustainable development status of a given system at a point in time, though they may describe aspects of the system based on a certain number of assumptions.⁴ The development of useful methods for evaluating the sustainability status of economic systems must therefore address the key characteristic of the concept which have brought the use of composite indexes into question.

In this article we take a view of sustainable development which is based on three of the most infrequently disputed characteristics of the concept is adopted. These are:

1. Sustainable development involves improving societal welfare through ensuring sustainable relationships between the heterogeneous capital stocks in economic and social production processes from one period to the next.
2. The stochastic interdependence between capital underlying the sustainable development process means that substitutability between capital types cannot be assumed to provide a solution for the need to ensure sustainable productive interactions between them.
3. The concept of sustainable development is still evolving which means that our ability to understand the dynamics of these relationships will change as our understanding of the concept develops.

Based on these observations we offer the following definition for sustainable development: sustainable development is a stochastic process involving socio-economic activities which are characterised by the realisation of indefinite inter-temporal welfare gains, either through ensuring the integrity and abundance of the inputs underpinning these activities, or through enabling sustainable interchange between them from one period to the next.

This definition addresses another contested, and contestable, aspect of the concept related to the use of the word development and the implicit assumption that it is possible to realise indefinite economic development. Again, this debate is well documented and transcends the scope of this article.⁵ This being noted, the article adopts the view that sustainable development is characterised by indefinite societal welfare gains where improving societal welfare is not necessarily or exclusively the product of economic growth.

The cornerstones of the view of sustainable development adopted above apply neatly to fisheries activities. This is because fisheries involve fishing activity conducted by agents seeking to realise economic and social welfare gains through efficiently harvesting depleteable renewable natural resources. The ability of fishers to conduct their business efficiently is dependent on a context characterised by stochastic interdependencies between socioeconomic, ecological, environmental and institutional capital underpinning the viability of their fishing efforts.

**Sustainable development assessment**

If systems of measurement for sustainable development are to provide practically useful decision support for policy makers they must take cognisance of the important undisputed cornerstones of the concept, and respond adequately to the challenges that these pose.

Systems of measurement for describing the sustainability status, or impact, of a given system, event or action must therefore account for the stochastic interdependencies between heterogeneous inputs underlying sustainable development processes, the resulting uncertainty about substitutability and the evolution of the concept.

Accordingly we propose a system of measurement which:

1. Describes the status of, or change in the status of, heterogeneous capital types underpinning the sustainable development of the given system.
2. Does not assume substitutability between capital types.
3. Provides for the evolution of sustainable development as a concept.

The approach adopts the use of dashboards for indication where a range of indicators are used to describe the status, or change in status, of factors affecting the sustainable development of a given economic, social or ecological system. As Joseph Stiglitz and Amaryta Sen and Jean-Paul Fitoussi have argued such dashboards are also useful when setting policy targets as they allow specific targets to be set for specific criteria.6

We call our approach as sustainable development directives (SDD). The SDD approach provides sustainable development decision support through repeatable iterations of measurement based on descriptive assessments which are provided conceptual orientation by the state of the art knowledge of sustainable development at every iteration. Through this process the SDD approach provides directives in respect refinable sustainable development trajectories. In so doing the SDD approach meets the first two criteria that we have set for sustainable development assessment methods, while accounting for the evolution of concept from one iteration to the next.

While we recognise the preference for complete sets of information, we also recognise the practical constraints on the availability of information. For this reason the SDD approach also allows flexibility where supporting data is very scarce. This is achieved through permitting the completeness of dashboards to evolve from one iteration to the next. Thus the essence of the SDD approach is the provision of directives which can be

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fine tuned over time and can therefore also be used in circumstances where information and research resources are scarce.

Francis Laloë has argued that a complete finite set of indicators that satisfies all institutional requirements cannot be achieved unless all of the information needs of decision makers are known. Since it may frequently be the case that this knowledge is not known, not least by the decision makers themselves, the usage of sets of indicators constituting an (incomplete) “base” for indication must be seen “as intermediate steps in the context of a decision process.” Jeffrey Sachs suggests that the means to providing the information necessary for subsequently fine tuning these trajectories will become available as the process of development takes hold. The first condition for this development to take hold requires an initial push in the right (general) direction. It is this directive push which has given the SDD methodology its name and identity.

In applying the SDD approach to the governance of Senegal’s marine fishery our objectives have been to assess and compare the sustainability performance of different fisheries’ activities. We have examined the sustainable development impacts of the fisheries activities undertaken by heterogeneous fishing sectors through identifying the impacts that each set of activity has on the conditions for the sustainable development of the fishery. This information is then used as management information for driving policy decisions toward the sustainable development of the fishery system.

Diagram 1.0 describes this process where the X axis denotes fishing effort (and/or cost) and the Y axis denotes the catch (and/or revenue) that can be realised as a function of fishing effort. The parabola represents the fish population growth curve along which all rates of catch equal the replacement rate of the fish population.

Points MSY (maximum sustainable yield) and MEY (maximum economic yield) refer to the fishing levels as which the maximum sustainable catch and maximum economic returns of fishing effort respectively, are realised. In the diagram we have introduced MSDY (maximum sustainable development yield), which refers to the level of fishing effort and catch which generates the greatest sustainable development benefit for the broader fishery system. This point is distinct from MSY and MEY as the conditions for sustainable development engender factors which may go beyond the maximisation of catch and or economic benefit. At MSDY capital endowments accord with the realisation of a sustainable development in accordance with contemporary knowledge of the concept. The point is therefore not fixed and can move in response to changes in our understanding of the requirements for the sustainable development of the system.

Lines A, B, C and D represent the aggregate average cost functions for fishing activities in respect of four average cost functions A, B, C and D. A represents an unsustainable rate of catch which is perceived not to correspond with the sustainable development of the system. It is at this point that a first iteration of the SDD assessment is conducted and provides policy makers with the decision support for defining policies aimed as moving fishing effort in the direction of B.

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8 Ibid. p 44.
At point Ac a decision is made to adjust the nature of the activity in order to place it on a more sustainable trajectory. This moves the function toward B. At B, a subsequent examination of the extent to which the economic activity accords with the perceived conditions for sustainable development is made, and fishing effort is directed toward C. The process is repeated until fishing effort is brought into line with MSDY.

While this sketch provides useful conceptual context for the SDD approach, in practice it is not feasible to produce accurate average cost functions in respect of these fishing activities.

In the case study which follows one iteration of the SDD approach is applies to Senegal’s marine fishery. While the results do not include a description of the average cost functions for the fishery, our findings are sufficient to provide decision support for shifting fishing effort toward MSDY.

**Senegal’s marine fishery**

Senegal’s approximate 196,000 km² surface area is situated on the south western flank of the Sahara Desert. The country’s coast line is approximately 700 kilometers long, and the waters covering the 27,600 square kilometres of continental shelf adjacent to this coast benefit from seasonal up-welling of cold, nutrient rich, water which nourishes West Africa’s natural wealth in marine life.\(^\text{10}\) Fisheries’ activities therefore form, and for many centuries have formed, an important part of economic life in and around Senegal.

Today it is widely believed that Senegal's fish stocks are under severe threat of depletion due to heavy fishing pressure on the country's fish stocks. This fishing pressure results from the activities of three main fishing sectors. These are the local artisanal sector, the local industrial sector, and the foreign industrial sector. Among the foreign industrial sector the most transparent activities are those which were conducted by the EU until the most recent protocol of the Senegal – EU agreement expired at the end of June 2006.

During 2004 – 2007 we used a simple SDD methodology to evaluate the impact made by each fishing group on the natural capital, social capital, economic capital and public institutional capital underpinning the sustainable development of Senegal’s marine fishery system.

We identified a set of quantitative indicators which could be used to evaluate the status, or change in status, of the four capital types supporting the sustainability of the fishing activities of the three main fishery user groups. Due to contextual limitations and data availability certain of the indicators identified were used as proxy indicators providing proxy indications in respect of the primary measurement target. For example, catch was incorporated as a proxy indicator for natural capital.

Accordingly each of the four capital types evaluated were measured as follows:

- **Natural capital (Kₙ):** catch as a percentage of the Maximum Sustainable Yield (MSY) for the particular fish stock.
- **Social capital (Kₛ):** employment created and catch for local consumption (as a contributing factor to food security).
- **Economic capital (Kₑ):** economic value added to the Senegalese economy.
- **Public institutional capital (Kₚᵢ):** financial contribution made to government.

In addition:

- Local landings were used to describe the locality of the benefits derived from landings and distinguish between landings for local consumption and landings for export.
- The regional distribution of landings was incorporated to describe the spatial distribution of economic and social (Kₑ and Kₘ) benefits relating to the distribution of landings made by the different fishery user groups, as well as the spatial distribution that may accrue to fisheries’ institutions.

Based on these indicators two tabulated data sets were compiled to described and compare the implications of fishing activities undertaken by the artisanal, local industrial, and EU industrial sectors in respect of the said indicators.

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12 The evaluation does not deal with the implications of non-EU foreign fishing fleets. This is because the activities of these fleets are not sufficiently transparent to warrant application of the empirical analysis employed in this study.

13 This indicator is provided context by describing whether each percentage corresponds to over or under exploitation. This is because certain percentages could represent both over and under exploitation depending on the ecological status the fish stock.
Table 12.1 First Tabulated Information Set of the SDD Approach: General Statistics For 2003

<table>
<thead>
<tr>
<th></th>
<th>Artisanal</th>
<th>Local Industrial</th>
<th>EU Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Catch (T)</td>
<td>386 000 T</td>
<td>42 400 T</td>
<td>11 900 T</td>
</tr>
<tr>
<td>Demersal Catch (T)</td>
<td>42 700 T</td>
<td>38 700 T</td>
<td>9 500 T</td>
</tr>
<tr>
<td>Small Pelagic Catch (T)</td>
<td>315 900 T</td>
<td>1 500 T</td>
<td>Very Negligible</td>
</tr>
<tr>
<td>Large Pelagic Catch (T)</td>
<td>6 400 T</td>
<td>1 500 T</td>
<td>2 500 T</td>
</tr>
<tr>
<td>Local Landings (T)</td>
<td>386 000 T</td>
<td>41 800 T</td>
<td>12 500 T</td>
</tr>
<tr>
<td>Geographical Distribution of Landings</td>
<td>7 Regions</td>
<td>1 Region</td>
<td>1 Region</td>
</tr>
<tr>
<td>Quantity of Catch for Export (T)</td>
<td>71 400 T</td>
<td>41 800 T</td>
<td>16 500 T</td>
</tr>
<tr>
<td>Landings for Local Consumption (T)</td>
<td>314 600 T</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Total direct Employment Created</td>
<td>90 000</td>
<td>5 300</td>
<td>300</td>
</tr>
<tr>
<td>Net Financial Contribution to Government</td>
<td>-7 407 Million F CFA</td>
<td>- 16 808 Million F CFA</td>
<td>10 495 Million F CFA</td>
</tr>
<tr>
<td>Value Added</td>
<td>63 320 Million F CFA</td>
<td>18 782 Million F CFA</td>
<td>16 363 Million F CFA</td>
</tr>
</tbody>
</table>

It is acknowledged that data in respect of fishery indicators, particularly catch data, have been criticised as being inaccurate and lacking credibility as a result of poor reporting of catches by EU vessels. Data relied upon for this examination was therefore sourced exclusively from studies commissioned or endorsed by the Senegalese government.\(^{15}\)

The first data set provides a ‘static’ indication of the implications of the fishing activities of each fishing sector. The ratios comprising the second data set are based on the data contained in Table 1.

Our evaluation demonstrates that artisanal sector activities accompany the greatest geographical distribution of landings, catch for local consumption, job creation and exports. However the sector performs poorly in respect of financial contributions to government.

The local industrial sector provides catch for export and negligible numbers of jobs, while costing the public budget significant sums in subsidies.

EU activities provide few jobs, but a significant contribution to the public budget, and a reasonable portion of catch for export compared with that provided by other sectors.


These observations were then elaborated upon with reference to the rates at which different outputs were produced. This process made it possible to provide an indication as to which sectors are more efficient in the production of different outputs.

Factors described by the second stage of the SDD approach are broken down into three main categories.

- Ratios describing catches made by each group as a percentage of the MSY for the given fish population.\(^{16}\)
- Ratios describing the efficiency with which sustainable development benefits were produced per ton of catch.
- Ratios describing the sectoral impact on each of the capital types per F CFA of economic value added.

A subsequent step involved qualitative information to be used as an early warning system for identifying potential threats to the sustainable development of the fishery. The potential threats resulting from the activities of the separate groups were described as follows:

- The probable balance of payments implications of different activities.
- The likelihood of capital flight (potential for the profits of fishing being invested abroad rather than in Senegal).
- The quality of employment provided (on board living conditions, general treatment of employees, prevalence of pension schemes and social benefits, and rates of pay).
- The usage of environmentally harmful fishing methods.

Based on qualitative insights gained through published opinions, interviews with stakeholders and fieldwork observations, one of three possible values was assigned to describe the likelihood of each risk. These values are: 'not problematic', 'potentially problematic' - requiring investigation, and 'clearly problematic' - requiring action.

The precautionary principle was used to mitigate against reckless usage of this system in two ways. The first way aimed to adopt a more cautious approach when making statements about the non-existence of a given sustainability risk. The second assists us to be cautious about adopting unnecessarily pessimistic views about the existence of a given sustainability risks.

For example, if there was any doubt about the existence of a sustainability threat posed by the activity of a particular group, the factor being investigated was immediately given a rating of 'potential threat'. If there was any evidence of this potential threat having clear negative consequences for the sustainability of the fishery, the factor being investigated was immediately rated more severely as posing a 'clear threat'. At the same time, if there was reasonable doubt regarding the existence of a clear negative consequence posed by a given factor, then that factor was assigned a rating of 'potential threat' warranting further investigation. The result of this mitigation process is that only

\(^{16}\)It is possible that a given population may be either over or under exploited at catch levels below MSY. For this reason additional indication was provided as a means to showing whether the population is moderately, fully, or over exploited.
clear immediate threats are rated as 'clear threats' warranting action, and only clearly sustainable activities are rated 'no threat'.

Based on this ensemble of information Table 2 below provides comparison between the implications of the fishing activities of the three user groups in question.

Table 2 Second Tabulated Information Set of the SDD Approach: Useful Ratios and other Qualitative Insights for 2003

<table>
<thead>
<tr>
<th></th>
<th>Artisanal</th>
<th>Local Industrial</th>
<th>EU Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Catch as % of Total MSY</td>
<td>80.42%</td>
<td>8.83%</td>
<td>2.48%</td>
</tr>
<tr>
<td>Demersal Catch as % of Demersal MSY</td>
<td>28.47% (over exploited)</td>
<td>27.73% (over exploited)</td>
<td>6.33% (over exploited)</td>
</tr>
<tr>
<td>Small Pelagic Catch as % of Small Pelagic MSY</td>
<td>70.20% (fully exploited)</td>
<td>0.34% (fully exploited)</td>
<td>Very Negligible</td>
</tr>
<tr>
<td>Large Pelagic Catch as % of Large Pelagic MSY</td>
<td>42.77% (fully exploited)</td>
<td>10.64% (fully exploited)</td>
<td>16.74% (fully exploited)</td>
</tr>
<tr>
<td>Employment per Ton of Catch</td>
<td>0.23 Jobs</td>
<td>0.13 Jobs</td>
<td>0.03 Jobs</td>
</tr>
<tr>
<td>Local Landings per Ton of Catch</td>
<td>1 T</td>
<td>0.99 T</td>
<td>1.06 T</td>
</tr>
<tr>
<td>Net Financial Contribution to Gov. per Ton of Catch</td>
<td>-0.02 M F CFA</td>
<td>-0.4 M CFA</td>
<td>0.88 M F CFA</td>
</tr>
<tr>
<td>VA per Ton of Catch</td>
<td>0.16 M F CFA</td>
<td>0.44 M F CFA</td>
<td>1.38 M F CFA</td>
</tr>
<tr>
<td>Employment per M F CFA of V.A.</td>
<td>1.5 Jobs</td>
<td>0.3 Jobs</td>
<td>0.02 Jobs</td>
</tr>
<tr>
<td>Local Landings per M F CFA of V.A.</td>
<td>6.1 T</td>
<td>2.23 T</td>
<td>0.76 T</td>
</tr>
<tr>
<td>Net Financial Contribution to Gov. per M F CFA of V.A.</td>
<td>-0.12 M F CFA</td>
<td>-0.89 M F CFA</td>
<td>0.64 M F CFA</td>
</tr>
<tr>
<td>Balance of Payments Potential</td>
<td>not problematic</td>
<td>potentially problematic</td>
<td>not problematic</td>
</tr>
<tr>
<td>Investment of Profits Abroad</td>
<td>not problematic</td>
<td>potentially problematic</td>
<td>not problematic</td>
</tr>
<tr>
<td>On-board Health and Safety</td>
<td>clearly problematic</td>
<td>potentially problematic</td>
<td>not problematic</td>
</tr>
<tr>
<td>Wastefulness of Fishing Methods</td>
<td>not problematic</td>
<td>clearly problematic</td>
<td>clearly problematic</td>
</tr>
</tbody>
</table>

Our results indicate that catches are generally close to MSY levels for all species groups. Catch for demersal species was seen as being below MSY levels, with qualitative accounts suggesting that catch levels are below MSY because these stocks are already over exploited. Qualitative information assessed during the study also suggest that small and large pelagic species were fully exploited.

The results show that the artisanal and local industrial sectors combined, exported almost thirteen times more fish products than the EU sector captured inside Senegal’s EEZ. The artisanal sector created roughly nine times less value added per ton of catch than the EU sector, while the local industrial sector created roughly three times less value added per ton of catch than the EU sector. This can be explained by the fact that artisanal sector catch composition is skewed towards low value species.

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17 This approach was implemented in response to growing awareness of issues surrounding a worst case scenario approach to fisheries’ information. These were outlined in Ray Hilborn's 2006 article titled 'Faith-based Fisheries', which discusses the problems posed to fisheries research as a result of sensational ‘worst case scenario’ information.

Simultaneously both local sectors made negative contributions to the public budget through the absorption of subsidies.

EU fishing activity was shown as placing negligible ecological pressure on the resources when compared with the impacts of other groups. At the same time the sector provided significant public revenue through the payment of licence fees and through special investments in monitoring and control, research and infrastructural development. Given the provision of financial and other resources that are seen to be necessary for the sustainable development of the fishery, the sector can be seen as playing a non-negligible role in the sustainable development of the fishery.

The sustainable development of the Senegalese maritime fishery could, therefore, be enhanced through capitalising upon the heterogeneous impacts stemming from the activities of the local artisanal sector and the EEC industrial sector. This can be achieved through three key policy actions:

1. Implementation of licensing arrangements which allow coordinated access for both groups.
2. Systematic downgrading of local industrial sector capitalisation through aggregative recapitalisation or buy-back schemes funded with receipts gained through access agreements with the EEC.
3. Simultaneously EC agreements can be phased downward while more effective licensing measures are phased in for the Senegalese artisanal sector, giving regulators an alternative source of revenue for managing the fishery, and developing capacity for more lucrative value added exports.

**Conclusion**

Like many sustainable development dilemmas, fisheries dilemmas are made particularly challenging by the number and range of interdependent forces impacting the sustainable development of fishery systems. These forces include micro economic rationalities driving the behaviour of fishing groups, interfaces between these actions and biological processes underpinning the ecological integrity of fishery populations, macro economic and public budget objectives, weather patterns, cultural norms, socio-economic influences and the political agendas of policy makers. This confusion of forces is further exacerbated by the lack of clear and effective measurement systems for providing objective policy measures supporting the sustainable development of the system.

The SDD approach is not a perfect solution to problem of providing objective decision support for guiding policy measures in sustainable development dilemmas. The approach does however respond to the primary challenges facing sustainable development assessment through adopting a flexible descriptive approach which creates space for the evolution of sustainable development as a concept. The application of this approach to the case of Senegal’s marine fishery clearly demonstrates the sustainable development impacts associated with the fishing activities of the user groups frequenting the fishery. The results of this study provide clear decision guiding measures for placing the fishery on a more sustainable trajectory. In so doing the assessment also provides an objective counterbalance to policy objectives which are based on agendas other than those intended to assure the sustainable development of the fishery system.
References


