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Abstract

Mitigation hierarchy is applied in many countries to avoid, reduce and compensate for impacts on the environment due to development projects. The design and sizing of measures thus depend directly on the assessment of impacts. However, this assessment is rarely framed by precise methods and is based on ad hoc evaluation that are carried out by environmental consultants by relying on own and more or less sophisticated methods. This article thus proposes to start from the ground up to analyse how impacts on biodiversity are assessed in practice, according to what method, and for what results. A statistical analysis was performed on 29 environmental assessments. We hypothesize that project size and number of species impacted are positively correlated with large impacts; and that measures and their costs are positively correlated with high impact reduction and low compensation. No correlation could be found for any of the factors studied. This result shows that there is considerable flexibility in the assessment of impacts, leading to inconsistent treatment of impacts. In the absence of a standardized method, this should encourage the adoption of sizing rules that compensate for uncertainties.

Keywords: Mitigation hierarchy, Biodiversity offsets, Evaluation of impacts, Sizing of measures, Flexibility

1. Introduction

The mitigation hierarchy is a land use planning tool that emerged in the United-States in 1970. It aims to conciliate biodiversity protection and development, as land artificialization is considered as one of the main causes of biodiversity decline (MEA, 2005; IPBES, 2019) and it is now a major policy instrument (Glasson and Therivel, 1999) which is used in about forty countries (BBOP, 2012). The goal of the mitigation hierarchy is to protect biodiversity, and to make sure that projects reach the "No Net Loss" objective, which means that losses from any project should be offset by at least equal gains of biodiversity. The usual process is to "avoid" impacts as much as possible; and to "reduce" impacts that could not be avoided. Finally, offset measures, defined as "actions designed to compensate for significant residual adverse biodiversity impacts arising from project development" (BBOP, 2009), are supposed to achieve the no net loss objective by obtaining "gains" of biodiversity. For instance, restoration of a habitat, or protection of a natural place that could have been destroyed, are considered as offset measures, as there is a gain of biodiversity compared to the baseline in which nothing is done.

The environmental impact assessment (EIA) is an important tool for the elaboration of the mitigation hierarchy for a land-use project, mandatory in the European Union for certain type of projects since 1985. It is an administrative document which is supposed to assess and define significant impacts of the project on biodiversity, and that is now a key instrument (Glasson and Therivel, 1999; Mandelik et al., 2005; Morgan, 2012). In the EIA, on-site species are inventoried, impacts on biodiversity are assessed, and mitigation measures are defined. The demonstration of the ecological equivalence and the achievement of the no net loss needs to be justified.

Despite its use in many countries, there are a lot of critics against the mitigation hierarchy that are reported in the international literature. First, some ethical considerations can be raised up, such as the fact that mitigation hierarchy could in practice remove the sense of responsibility towards nature's protection (Moreno-Mateos et al., 2015), become a "licence to trash" (McKenney and Kiesecker, 2010), or even exacerbate biodiversity decline by giving false public confidence (Gordon et al., 2015) and too much optimism for technological solutions (Moreno- Mateos et al., 2015).

Moreover, even if we assume that mitigation hierarchy is an efficient tool for biodiversity conservation, its execution raises other limitations. The avoidance of impacts, which is supposed to be the most efficient and priority part of the mitigation hierarchy (Ekstrom and Pilgrim, 2014; McKenney and Kiesecker, 2010) is poorly applied (Gelot and Bigard, 2021; Phalan et al., 2018). The scale of the mitigation hierarchy application is often defined without ecological considerations (Geneletti, 2006). It applies mainly to species – but not all species (Bigard et al., 2017a; Guillet and Semal, 2018; Pellegrin et al., 2018) and ecological functionalities are rarely considered (Chaurand et al., 2019; Quetier and ´ Lavorel, 2011).

One of the main critics of the mitigation hierarchy is about the ecological equivalence. Formal methods are required for assessing ecological equivalence (Qu´etier and Lavorel, 2011). But in most countries, there is no standard methodology, indicators or metrics (Geneletti, 2006; Qu´etier et al., 2015a), which makes it difficult for both developers and administrative authorities to ensure the no net loss and to scale the offset measures (Jacob et al., 2015; Mechin and Pioch, 2019). Moreover, there are rarely monitoring or feedbacks once the projects are authorized (Bigard et al., 2017a; Briggs and Hudson, 2013), while it would be very important to assess the efficiency of offsetting measures and allow a better scaling of the mitigation hierarchy for future projects (Regnery et al., 2013). Finally, offsetting gains are often uncertain, due to technological difficulties, to a lack of monitoring (Maron et al., 2016; Quetier et al., 2015b´ ; Vanpeene-Bruhier et al., 2013; Weissgerber et al., 2019). The principle of additionnality, that is to say the fact that offsetting measures should be added to on-going measures or policies instead of replacing them, is not always fullfilled (Levrel et al., 2018).

The prolific literature on mitigation hierarchy does not properly address the question of how impacts are actually assessed. However, this exercise constitutes the heart of mitigation hierarchy since the measures must be sized according to the level of impact. It is cited as one of the weaknesses of EIAs (Treweek, 1996). The impact assessment requires two steps: to predict what impacts the projects will have on the environment and species (and to describe it, quantitatively or qualitatively), and to qualify the level of significance (Geneletti, 2006; Thompson, 1990). Various problems can be raised up: lack of ecological details and comprehension (Briggs and Hudson, 2013), difficulty to define what a "significant impact" is (Bigard et al., 2017b; Geneletti, 2006; George, 1999), or subjectivity of the judgment, which is necessary (Wilkins, 2003) but controversial (Treweek, 1996). While most national mitigation hierarchy policies do not have a standardized impact assessment method, the actual practice relies mainly on the capabilities of the consulting firms that carry out the assessments, and on the control of the environmental administration. Can such a system guarantee quality and consistency in impact assessment? We thus analysed the methods and results of impact assessment in EIAs.

To analyse the actual practices of impacts assessment, we focused on the case of the French policy where there is no standardized method. In France, the principle of the environmental assessment and of the mitigation hierarchy was adopted in a law for the nature's protection in 1976, stating that every development project that could impact natural habitat and biodiversity should make an EIA including initial state of the site, impact assessment and mitigation measures. The law on impact studies was strengthened in 2007 to bring it into line with European environmental law. This led to a more widespread implementation of the mitigation hiearchy sequence and to the need for technical guidelines and standards. A new policy in June 2012 reformed the procedure and associated with national doctrine and guidelines allowed a better implementation of the mitigation hierarchy (Bigard et al., 2017b).

Even if EIAs quality improved with the policy changes and official guidelines, some shortcomings are still identified. In particular, several studies focus on the ecological equivalence, to propose methodologies (Bezombes and Regnery, 2019; Qu´etier et al., 2015a) or to highlight some recurrent shortcomings (Bigard et al., 2017b; Quetier et al., ´ 2015b); but the impact assessment itself is poorly studied. Therefore, the objective of this study is to focus on the way impacts on biodiversity and the reduction of these impacts are assessed in French EIAs. In addition to the work that proposes methodologies and frameworks for assessing impacts and measures (Bezombes, 2018; Joseph W. Bull et al., 2013), our contribution to the mitigation hierarchy scholar consists of starting from the ground up to analyse how impacts are assessed in practice, according to what method, and for what results. We studied EIAs from four French regions; Provence-Alpes-Cote-d'Azur, ˆ Midi-Pyr´enees, ´ Languedoc-Roussillon, and Hauts-de-France. We focused on the protected species procedure, a particular procedure for projects that will affect protected species, for linear infrastructure and development zone projects. We studied the way the impacts, but also the reduction of these impacts, are assessed. We tried to understand how the impact reduction was justified in the EIAs, mainly by linking it with other characteristics of the EIAs in order to test their regularity.

We focused on the type of projects, the number of species on which impacts are assessed, the quantity and quality of measures, the cost of mitigation measures, the cost of mitigation measures per hectare. Indeed, the mitigation measures are the only elements justifying the impacts decrease in the EIAs – we then assumed that there would be a positive correlation between the quantity and quality of attenuation measures and the impacts decrease assessment. We assume that the cost of mitigation measures is correlated to a significant reduction in impacts. In fact, the environmental administration

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often considers the cost of measures as a guarantee of the seriousness of EIE. This generally concerns high-impact projects that have to build up their legitimacy. We also assumed that impacts, and therefore impacts decrease, could be assessed differently depending on the type of project. Finally, we chose to study the number of species on which impacts are assessed because residual impacts – and thus offsetting measures – usually concern few species, as we will discuss later.

2. Material and methods

2.1. Material

We studied the protected species procedure of 48 EIAs from four regions of France: Midi-Pyren´ ´ees (MP, 17 projects), Languedoc- Roussillon (LR, 12 projects), Hauts-de-France (HDF, 15 projects) and Provence-Alpes-Cotes-d'Azur (PACA, 4 projects). A law on territorial ˆ governance led to the merger of the Midi-Pyrenees and Languedoc Roussillon regions in 2016. However, in a context where evaluation methods are not very standardized, the professionals involved develop collective work habits. In other words, they built local references and methods that can influence impact assessment practices and results. We have therefore retained the four regions to take this potential variation factor into account. We chose to focus on the protected species procedure because this particular procedure usually involves a complete implementation of the mitigation hierarchy – including offsetting measures. Moreover, the protected species procedure is carried out when projects are impacted more sensitive habitats or species and is then supposed to be more rigorous. An accurate assessment of the impacts can therefore be expected.

The projects we studied are all linear transport infrastructure projects (LI, 23 projects) or activities and housing area projects (AP, 25 projects). The documents were obtained thanks to the Regional Environmental administration of each region (DREAL). These environmental state services are responsible to examine the impact assessments, check their validity and, if necessary, request modifications before drafting the project authorisation order.

These EIAs were all handed over to the authorities between 2014 and 2022 (after the publication of the main doctrine and guidelines). They impact various areas with surface from 1 ha to 400 ha. Linear infrastructure projects are mainly roads and maintenance projects, with also canals, underground and cable car; and AP projects are mainly housing places, commercial areas, or warehouses.

All projects except 6 were already authorized by administrative authorities; 1 was not authorized and 5 are still in instruction.

2.2. Data collection

For each project, we extracted various characteristics, and in particular the type of project, the region, the surface of the project, the impact assessment method, the number of species highly, moderately, or poorly impacted, the list of the mitigation measures that are defined, the number of mitigation measures and their cost (as how much the measures will cost to the project maker is usually assessed).

There are usually two impacts assessments in the EIAs: the initial impacts, which are the impacts that would occur if there were no mitigation hierarchy; and the residual impacts, which are the remaining impacts after the mitigation measures. The residual impacts are the impacts that, if they are significant, need to be offset. Impacts are usually ranked from very low to very high, or from low to high; and an impact is considered significant from low or medium impact (depending on the EIA, and sometimes on status of the species).

Depending on EIAs, impacts can be assessed for one or a few species only; for every species or protected species; or qualified by themselves (for instance, “destruction of habitat is a high impact”). We focused on EIAs in which impacts are assessed for several species, for both initial and residual impacts, as the aim of the study is to analyse the decrease of impact on species before and after mitigation measures. In some EIAs, impacts were assessed for groups of species and not for each species. In these cases, we chose to consider that each species was impacted the way the group is (for instance if bats are highly impacted, and 12 bat species were inventoried on the project area, then we consider that 12 species are highly impacted). It is worth noting that from an ecological perspective, the population size of the species present would provide much more relevant information for assessing impacts in terms of population viability. However, this information is rarely provided in EIAs. The number of species is the only variable that can be used to approximate the biological diversity of the impacted sites.

For these reasons, we had to remove several EIAs from our samples, because impacts were not assessed on species (or on enough species), or because only residual impacts were details. It Is worth noting here that this is an indication of the uneven quality of the files. Thus, the study could be conducted on 29 EIAs: 12 LI projects (4 in HDF, 4 in LR, 4 in MP) and 17 AP projects (4 in HDF, 7 in LR, 2 in MP and 4 in PACA).

2.3. Index of impact on biodiversity

To study quantitatively the reduction of the impact before and after mitigation measures, we built an index representing the proportion of species impacted by the project. This index goes from 0 to 1. It equals 1 when every species considered is very highly impacted; and 0 when every species considered is non impacted.

There are two types of scales for the impact description in EIAs: from impacts “very important” to “very weak”, and from “important” to “weak”. We chose to separate these two cases.

In the case of a scale from “very important impacts” to “very weak impacts”, the index is defined as

$$I = \frac{X1 + \frac{4}{5}*X2 + \frac{3}{5}*X3 + \frac{2}{5}*X4 + \frac{1}{5}*X5}{X1 + X2 + X3 + X4 + X5 + X6},$$

with X1 the number of species very highly impacted, X2 the number of species highly impacted, X3 the number of species moderately impacted, X4 the number of species weakly impacted, X5 the number of species very weakly impacted, and X6 the number of species on which the impact is assessed, but considered as null.

In the case of a scale from “important” to “weak” impacts, the index is defined as

$$I = \frac{X1 + \frac{2}{3}*X2 + \frac{1}{3}*X3}{X1 + X2 + X3 + X4}$$

with X1 the number of species highly impacted, X2 the number of species moderately impacted, X3 the number of species weakly impacted, and X4 the number of species on which the impact is assessed as null.

This index only qualifies predicted impacts as they are assessed in the protected species procedures. It does not report on the reality of the impact; only on how important the assessor supposed the impacts would be.

We focused on how this index decreases after the mitigation measures, in percentage. This index decrease also reflects the decrease of the number of impacted species, in percentage.

2.4. Analysis

We tested the correlations between the index decrease, and other characteristics of the EIAs that could – or should – explain the decrease of impacts (or the way it is assessed). The characteristics we focused on are the type of projects, the cost of mitigation measures, the cost of mitigation measures per hectare, and the number of species on which impacts are assessed. We tested each of the four characteristics independently from the three others.

We used Wilcoxon test to study whether there is a significant difference between the index decrease in LI projects and AP projects, with the usual *p*-value of 0.05.

The other characteristics (cost of mitigation measures, cost of mitigation measures per hectare, and number of species on which impacts are assessed)

are all numeric, but not necessary normally distributed. Moreover, for the three variables, we can assume that if there is a correlation, it will be a monotonic one.

Indeed, mitigation measures are made to reduce the impacts on biodiversity. We do not expect a linear relation between the costs and the impact decrease, as the outcomes of measures are not directly proportional with their cost. However, we can assume that if the cost is correlated with the impact decrease, it is a positive correlation: the higher the costs, the more important the reduction of impacts thanks to the mitigation measures. Indeed, most of EIAs propose similar mitigation measures (for instance, a particular type of night lightning to avoid disturbance on chiropters, or limitation of the propagation of exotic species), that should have similar costs (or similar costs by hectare). We then expect that EIAs with much more expensive mitigation measures should have greater reduction of the impacts. We can have the same thinking for the cost of measures per hectare. We chose to use both cost and cost per hectares as proxies for impact reduction effort.

The number of species that are concerned by offsetting measures is usually very low, even when there are a lot of species inventoried or on which impacts are assessed. We assumed that if there was a correlation between index decrease and the number of species on which impacts are assessed, it would be a positive one: if there are many species on which impacts are assessed but very few species on which final impacts are significant, impact reduction must be very important.

Therefore, we chose to use the Spearman correlation test, as it is a non-parametric test appropriate for non-normally distributed values, that can test the significance of a monotonic relation – and its coefficient. We used a significance level of 0.05.

Statistical analyses were made using R version 4.0.4 on RStudio. Wilcoxon test was made with the function "wilcox.test", and Spearman correlation test with the function "cor.test(method = 'spearman')". They were conducted on 27 environmental assessments, as the impacted surface was not defined for two of the projects.

3. Results

3.1. Impact assessment method

We conducted our study only on the EIAs in which impacts are assessed for a great number of species, and on every species or group of species (e.g., chiropters, insects). It represents 29 EIAs of the initial 48 EIAs (60 %). In these EIAs, impacts are assessed on every species (6 EIAs), on every protected species but not those unprotected (22 EIAs), or on solely "conservation concern" species (1 EIA).

In 18 EIAs, impacts are assessed for each species individually; while on the other 11, impacts are assessed for each group of species.

Impacts are always qualitatively described. For 17 EIAs, figures are given, such as the number of individuals that might be destroyed or disturbed, or the area that will be impacted, but the way these figures are assessed is not explained.

The scale used for the impact assessment is never explained in the EIAs. There is no explanation either for the corresponding between the qualitative description of an impact or the figures associated (the impact prediction) and the impact level (the impact assessment). Significance is not justified either.

3.2. Index of impact on biodiversity, and decrease of the index

In both cases, there is a large range of values: from 0.3 to 0.8 before mitigating; from almost 0 to 0.7 after mitigating. The level of initial impact and the estimation of impacts after mitigation measures appears to be very variable from one file to another. There is a clear decrease of the index before and after mitigation measures. In accordance with the theoretical logic of mitigation hierarchy, mitigation measures do reduce impacts.

We can observe an even higher variability of the index decrease, with percentages of decrease from 0 % to 98 %. 0 % means that there are no changes between initial and residual impacts; their intensities are assessed as equal. 98 % of index decrease means that almost all the impacts were avoided and went from whatever level to "neglectable" – except for one or two species. There is a whole gradient between these extreme values, with an average index decrease of 39 %, and a median of 34 %.

3.3. Statistical tests

The distribution of the index decrease depending on the type of projects is presented on the following chart.

The Wilcoxon-test used to compare activities and housing area projects (AP) and linear infrastructures (LI) projects resulted in a *p*-value of 0.023, which is significant: the decrease of the impacts on biodiversity is significantly different (and higher) for LI projects than for AP projects. Still, it is important to note there are some outliers in each type of projects.

We then tested the correlation between the index decrease and the cost of avoiding and reducing measures; the number of species considered; and the cost of measures per hectares.

The plots of data are presented, for each variable, in the following figures.

For the cost of mitigation measures, the value of rho was of 0.16, and the *p*-value was 0.48. For the cost of mitigation measures per hectare, the value of rho was of 0.23, and the p-value was 0.26. For the number of species on which impacts are assessed, the value of rho was of 0.03 and the p-value 0.89. Finally, for the variable "surface", the value of rho was of − 0.27, and the p-value was 0.17. (See Fig. 1.)

The p-value for Spearman correlation test is far from the significance level of 0.05 in the three cases, and the value of the rho is always positive, but weak. Therefore, we cannot conclude in the existence of a significant positive correlation. As it stands, the reduction of impacts cannot be explained by the financial amounts invested in the measures, or even the costs per hectare. The reduction of impacts does not seem to depend significantly on the number of species assessed either.

3.3.1. Analysis of mitigation measures

We extracted mitigation measures from every EIA studied. Many measures are very usual, and defined in almost every file: that is for instance the case for adapting the building calendar to avoid sensibility periods of specific species (most of the time because of breeding period), protecting especially sensitive areas, avoiding the spread of exotic invading species, etc. These are the mitigation measures that are also indicated in the official guidelines, and that are then well defined, well known, and easy to justify. In some files, some fewer common measures are also defined.

We found that the EIAs proposing the most ambitious mitigation measures (a larger number of measures, with not only usual measures) were not necessarily the ones with the highest decrease of the impact on biodiversity index.

We had a particular attention for EIAs with extreme index decrease: more than 85 % (3 EIAs) or less than 5 % (2 EIAs, including 2 for which the index decrease is of 0 %). In the 3 EIAs with the most important index decrease, 1 EIA defines original measures we could not find in other cases, one defines a few more measures than the usual ones; and the last one defines only usual measures. For those with the fewest index decrease, one defines only usual measures, while the two other ones define a few more measures than the usual ones. Therefore, there is not a clear difference between mitigation measures from the EIAs with the highest index decrease nor with the fewest index decrease.

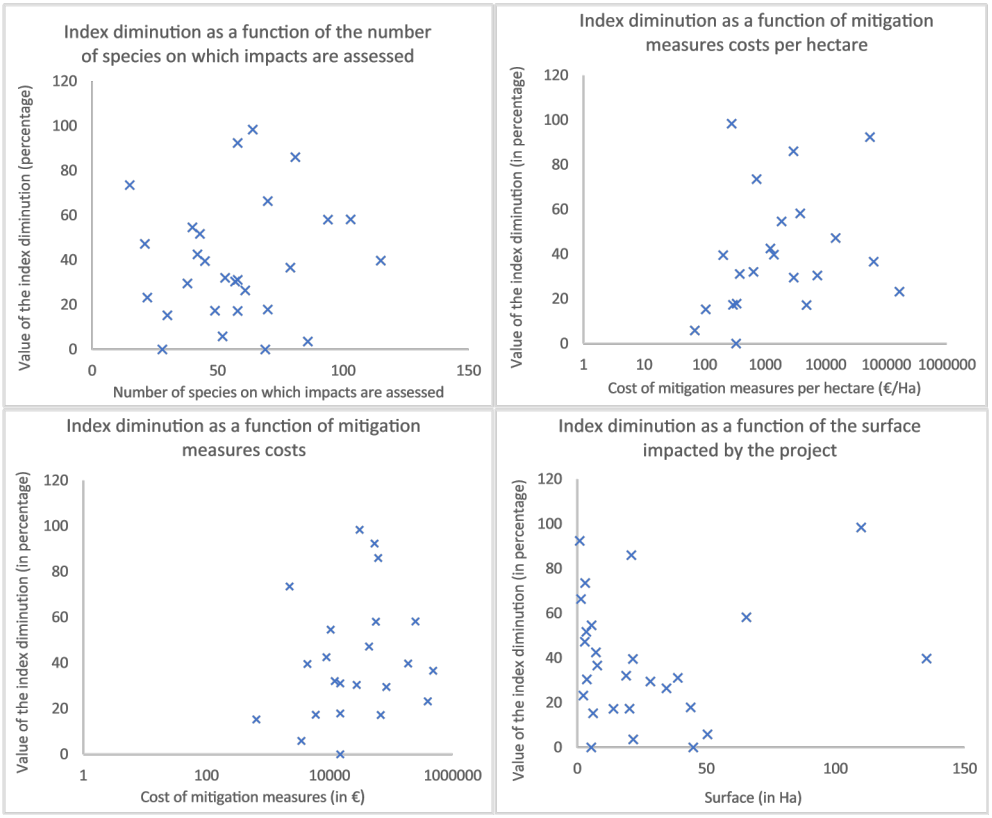

Fig. 1. a) Index diminution depending on the cost of mitigation measures (logarithm scale), b) Index diminution depending on the cost of mitigation measures per hectare (logarithm scale), c) Index diminution depending on the number of species on which impacts are assessed, d) Index diminution depending on the surface that may be impacted by the project.

4. Discussion

4.1. An arbitrary impact assessment

According to the theoretical logic underpinning the mitigation hierarchy, the initial level of impact depends on the surface area of the projects, the sensitivity of the local environment and the number of protected and endangered species affected. It can be expected that projects of a similar size (or by analyzing proportionally to the surface) and in the same territory present an equivalent level of impact. Then, according to the principles of mitigation hierarchy, the avoidance and reduction measures allow to anticipate a reduction of the impacts. A strong correlation can therefore be expected between the quantity and quality of measures and the level of impact reduction. However, our results show very little consistency and high variability in the estimation of initial impacts and impact reductions, and finally very low correlation between promised measures and impact reduction.

Concerning the variability in impact reduction, the range of the index decrease series, from 0 to 98 %, is particularly interesting in that they show that the evaluations resemble an exercise in arbitration or approximation. Extreme values are a nonsense. Indeed, mitigation measures are defined to reduce impacts on biodiversity; an index decrease of 0 % means no reduction is achieved even if measures are implemented – as projects with a very weak index decrease still define measures. The guidelines and law on the mitigation hierarchy state that offsetting should occur only after efforts were made to avoid and reduce impacts – which is not the case when the index does not decrease at all. On the opposite, a reduction of 98 % of the impacts could be qualified more like an avoidance than a reduction. This would mean the project has no impact on biodiversity anymore, which is a nonsense as we are working on urban development projects replacing natural or semi- natural habitats.

Concerning excepted correlations between efforts invest in mitigation measures and impact reduction, all tests show weak relations. It is worth reminding that statistically, we cannot show that there is strictly no correlation between the characteristics selected and the index decrease. Moreover, the sample size is quite low, and it could be interested to conduct a similar analysis with more EIAs. However, our results show that if there is a correlation, it is not a strong one (given the values of the rho) and it is not significant with the sample we studied. Qualitatively, we cannot link ambitious and numerous mitigation measures to the most important index decreases. Therefore, even if the quality and the scaling of the measures impact the index decrease, they are far from well explaining the variability of our series.

The cost of the measures could have provided indications according to two mechanisms: a high cost translates an important effort to strongly reduce the impacts; it can however translate a strategic display aiming at legitimizing a project with strong impact. The tests do not allow to advance on these hypotheses insofar as it does not appear a correlation between the cost of the measures and the reduction of the impacts. It should also be added that ecological measures can be low cost but effective. Finally, the information contained in the files makes a precise analysis difficult insofar it is presented in different and not very comparable ways. However, cost can still be expected to be a proxy for impact reduction effort, especially for very expensive measures for which an impact reduction should be expected.

We could not find any other coherent explanatory variable in the files, as the definition of mitigation measures is the only part of the EIAs between the two impacts assessments, and mitigation measures are the one thing supposed to allow an impact reduction. Moreover, we also saw that the method of the impacts assessment is rarely defined. Impacts are often described (predicted in the sense of (Geneletti, 2006), but there is no defined scale for the assessment itself. What is a “high” or a “low” impact is not precisely qualified; nor what a “significant impact” is. Even when precise information is provided (such as the number of individuals destroyed or disturbed and the exact impacted surface), there is no precision on how it was calculated, or on how it is linked with the impact scale.

We can then emit the hypothesis that the assessments of impacts and impacts decrease are either arbitrary or not funded on the right explanatory variables and on precise scientific arguments. This corroborates previous results stating that significance and impact scale are most of the time poorly defined (Bigard et al., 2017a; Geneletti, 2006; George, 1999).

4.2. An important gap between the strict framework and the quality of the ecological content

The study showcases an important the gap between the very formal and strictly defined framework of the EIAs, and their scientific content. In France, the framework and the global content of EIAs are precisely defined (de Billy et al., 2020; Hubert and Morandeau, 2013). They are quite the same for every project, they do not vary from an environmental consultant office to another. A lot of definitions, a strict regulatory frame, a precise description of the project, are systematically given. The inventories methods are usually widely described, with a lot of qualitative and/or quantitative details. Measures are also often described very precisely.

However, when it comes to the justification of the ecological equivalence, which is supposed to be the core of the mitigation hiearchy, way less details are given. Yet, many studies have been made on how to justify, or to propose some methods (Bezombes and Regnery, 2019; Qu´etier et al., 2015a) - but in practice, even if impacts are usually quite well described, the assessments are poorly justified. The decrease of the impacts, and the link of this decrease with the measures, is even less detailed. If the assessment of significant impacts is not based on scientific justifications and methods, or if instructor services cannot check the reliability of the assessments, then it is impossible to ensure the NNL achievement. Moreover, our study completes studies on the gains assessments, stating that gains are uncertain, insufficient or poorly assessed (Joseph W. Bull et al., 2016; Moreno-Mateos et al., 2015; Weissgerber et al., 2019). If both losses and gains are unreliably assessed, the ecological equivalence is highly uncertain.

4.3. A hidden flexibility that facilitate the implementation but could cause erratic results

This absence of justification and the apparent arbitrariness of the assessment could for a part at least be linked to the absence of a precise method that would have been imposed to the consultants by the instructor services (Grimm and Koppel, 2019). We propose to consider this flexibility in impact assessment as a hidden flexibility, in reference to the flexibility allowed by the rules of application of mitigation hierarchy. Flexibility is seen in the literature as a lever for enhancing the ecological effectiveness of measures and achieving no net loss. However, the conditions for success are very demanding and the risks of reduced ecological effectiveness high (J. W. Bull et al., 2015; Shumway et al., 2023). It has been shown that the regulator tends to increase the ecological, geographic, or temporal flexibility of mitigation implementation rules over time to meet non-ecological objectives such as improving the function of market-based compensation mechanisms by facilitating trade in a context of land tension (Needham et al., 2019; zu Ermgassen et al., 2020). We show that, in addition to formal flexibility rules that can affect the achievement of no net loss, there are forms of hidden flexibility which, although they provide a fluidity that facilitates the implementation of the policy, can produce erratic results in terms of impact assessment and dimensioning of measures.

Reducing the effects of hidden flexibility raises the important question of the necessity – or not – of a unified method at the national scale, that would appear in the governmental guidelines, as it is now the case for the measure's definition for instance. Qualitative studies can appear to be more subjective and less trustworthy than quantitative ones (Wilkins, 2003). They are sometimes percepted as biased and subjective (Lawrence, 1993) – and particularly in the case of EIAs, as they can be considered as political tools, and as assessors are employed by those who lead the projects (Beattie, 1995; Gilpin, 1995; Wilkins, 2003)). A quantitative assessment would appear less subjective and as it could not be biased by political pressures. Moreover, the multiplication of methods and the absence of a clear presentation of these methods in EIAs make the instruction by instructor services complex, especially as these services are saturating in France (Guillet and Semal, 2018). Moreover, when different methods give different results, project makers can negotiate

and choose the method that will allow them to do as few efforts as possible (de Billy et al., 2020; Calvet, 2015). Parallelly, it is more difficult for instructor services to ask for more measures as there are no officially defined objectives and methods (Guillet and Semal, 2018). An imposed method reduce the possibility of political pressures and opportunistic choices as it is shown in S. Barral (2020) which compared the methods for developing biodiversity measures in France and the United States (Barral, 2020). For each species actually protected in practice, the equivalence agreement between impacts and gains is formalized upstream by the State services and applied in a homogeneous manner to all development projects. The comparison of the French and American cases shows that the most simplified and standardized system is better equipped to limit the power games at work and the minimization of conservation actions, testifying to a major tension between simplification of the issues and effectiveness of the action.

In addition to the issues of framing negotiations and limiting political strategies, the standardization of impact assessment methods raises issues of reliability and relevance of quantitative and qualitative methods, which makes it difficult to arbitrate definitively.

This question has been studied for the case of *multipliers*, or compensation ratios. Multipliers are figures used to size the offset measures, that can be determined with various quantitative methods. They are supposed to allow the inclusion of time delay between impacts and offsetting (Joseph W. Bull et al., 2016; McOverton et al., 2013), the uncertainty of the gains (Joseph W. Bull et al., 2016), and to have an easy and explicit method that can be imposed to everyone (Brownlie and Botha, 2009). Moreover, McKenney and Kiesecker highlight the fact that the use of a quantitative method to define multipliers and then size the offset measures ensures to have a non-biased method, while determining multipliers "based on professional judgment is too often an ad hoc and opaque process [which] makes it difficult to ascertain the degree to which decisions are science based and unbiased" (McKenney and Kiesecker, 2010). Quantitative definition of multipliers has then some clear advantages to ensure the quality of the offset measures sizing. But even if many studies were made on this subject, multipliers are still poorly used and defined. They are generally underestimated (Joseph W. Bull et al., 2016; McKenney and Kiesecker, 2010), with insufficient performances that are not audited for now (Brownlie and Botha, 2009). This last point shows that quantitative and standardized methods will not bring efficiency if they are not supported by an adapted governance.

On the other hand, assessment based on "professional judgment" can also be important, and allows more flexibility, which can allow to be more adapted to the specificities of each location (Kareiva and Fuller, 2016). Environmental consultants have their own methods and their own ecological knowledge, often locally implanted, that can be as useful and precise as a unique scientific method that would be applied in the whole country. Moreover, a territorial approach could allow considering the specificities of each region. Imposing a unique method would miss important elements specific to each area, and then make uncertain the achievement of the ecological equivalence.

It is then similar to the debate between quantitative and qualitative method: risk of pressure and bias, negotiation and underestimating measures size, false scientific justification, on one hand, and the fact that unique or quantitative methods do not ensure quality either.

Finally, the debate on quantitative or qualitative methods, more or less standardized, involves different issues and remains difficult to arbitrate: risk of pressure and bias, negotiation and underestimation of the size of measurements, false scientific justification. Conversely, single or quantitative methods are not a guarantee of quality either. It would be illusory to demand perfectly comprehensive data collection and the implementation of perfect, sophisticated methods in all EIAs. However, it would be desirable for uncertainties to be explicitly highlighted in EIAs so that the policy decision incorporates uncertainties and risks, and to allow for more appropriate sizing of mitigation measures. Thus, if multipliers are used, they should be higher to incorporate uncertainty (Arlidge et al., 2018; Joseph W. Bull et al., 2013). Ultimately, it is not necessarily quantitative assessment that is lacking in EIAs, but more transparency about how assessments are conducted, and the existence of strong governance to require sizing of measures accordingly.

5. Conclusion

The impact assessment is at the core of the mitigation hierarchy, as the aim of the mitigation hierarchy is to reduce the impacts as much as possible, and to compensate those which are assessed as significant. Therefore, in this article, we tried to understand how the impacts are assessed, and how their reduction is justified. More precisely, we focused on the link between the impact reduction, and what is supposed to explain it: the mitigation measures.

But the methodology for impact assessment is rarely defined or clearly exposed; and the impact reduction cannot be linked with the importance of mitigation measures. Therefore, even if EIAs are significant documents with a lot of scientific data and references, the impact assessment itself seems to be based on arbitrary analysis or opaque criteria. We refer to this flexibility in impact assessment as hidden flexibility. While this flexibility facilitates policy implementation, it could have the effect of underestimating impacts and therefore offsets. This raises the question of the independence of the consulting firm and the transparency of the management of uncertainties in the assessment of impacts and the dimensioning of measures.

CRediT authorship contribution statement

Zoe Pelta: ´ Methodology, Software, Validation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Yves Bas:** Methodology, Software, Validation, Formal analysis, Investigation, Writing – review & editing. **Fanny Guillet:** Conceptualization, Validation, Investigation, Resources, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The article presents an original and non-published research firstly submitted to Biological Conservation and non-submitted elsewhere. This article has no conflict of interest.

Data availability

Data will be made available on request.

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