

## Research article

# How much of a market is involved in a biodiversity offset? A typology of biodiversity offset policies



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## ABSTRACT

Biodiversity offsets (BO) are increasingly promoted and adopted by governments and companies worldwide as a policy instrument to compensate for biodiversity losses from infrastructure development projects. BO are often classified as ‘market-based instruments’ both by proponents and critics, but this representation fails to capture the varieties of how BO policies actually operate. To provide a framing for understanding the empirical diversity of BO policy designs, we present an ideal-typical typology based on the institutions from which BO is organised: *Public Agency*, *Mandatory Market* and *Voluntary Offset*. With cross-case comparison and stakeholder mapping, we identified the institutional arrangements of six BO policies to analyse how the biodiversity losses and gains are decided. Based on these results, we examined how these six policies relate to the BO ideal types. Our results suggested that the government, contrary to received wisdom, plays a key role not just in enforcing mandatory policies but also in determining the supply and demand of biodiversity units, supervising the transaction or granting legitimacy to the compensation site. Mandatory BO policies can be anything from pure government regulations defining industry liabilities to liability-driven markets where choice sets for trading credits are constrained and biodiversity credit prices are negotiated under state supervision. It is important to distinguish between two processes in BO: the matching of biodiversity losses and gains (commensurability) and the trading of biodiversity credits (commodification). We conclude that the commensurability of natural capital is restricted in BO policies; biodiversity is always exchanged with biodiversity. However, different degrees of commodification are possible, depending on the policy design and role of price signals in trading credits. Like payments for ecosystem services, the price of a biodiversity credit is most commonly based on the cost of management measures rather than the ‘value’ of biodiversity; which corresponds to a low degree of commodification.

## 1. Introduction

During the previous decade, there has been a growing interest in biodiversity offsetting<sup>1</sup> (BO) as a novel policy instrument for financing biodiversity conservation. BO aims to compensate for the biodiversity losses that occur in one place from economic activities, by requiring the developers (involved in natural resource exploitation) to fund the costs of environmental protection or restoration activities somewhere else (Dempsey and Collard, 2017). Policies for offsetting biodiversity losses are used in at least 33 countries around the world, cumulatively restoring and protecting 8.3 million ha of land (Bennett et al., 2017). The widespread use of biodiversity offsets has been led by three principal drivers: 1) Legislation and policies encouraging compensation by

national governments, the European Commission (2011) and the Convention on Biological Diversity (2008); 2) Global financial institutions that require biodiversity offsets to be considered as a condition of being granted funding (World Bank, 2017; IFC, 2012); and 3) Voluntary commitments from corporations pre-emptively managing business risks (Rainey et al., 2015; BBOP, 2012).

A central debate exists between market versus state approaches to environmental governance, with markets being perceived as more efficient than the traditional command-and-control policies that often characterise natural resource management schemes (Stavins and Whitehead, 1997). Biodiversity loss is framed in this debate as a negative externality, where instruments such as BO and payments for ecosystem services are part of a trend incorporating the polluter-pays

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<sup>1</sup> We use the terms ‘biodiversity offsets’ interchangeably with ‘ecological compensation’ for ease of reading, although we do acknowledge the difference between them. Offsetting implies that the losses and gains of biodiversity values are quantified for measurable conservation outcomes, while ecological compensation involves a range of measures to recompense without necessarily having a strict measurable goal (Bennett et al., 2017).

principle and market mechanisms to conservation (Alvarado-Quesada et al., 2014; Jenkins et al., 2004).

However, the use of BO and economic framing in biodiversity conservation has been contested. Assigning a monetary value to things such as biodiversity and ecosystem services has been criticised as the expansion through commodification (Hahn et al., 2015) of the market economy into the domain of nature. There is a long tradition of thought that emphasises how commodification undermines social morality and public benefits (see Hirschman [1986] for a historical overview). The underlying idea is that economic valuation methods and market principles are not ideologically neutral; they embody an individualistic, competitive logic that incentivises self-regarding behaviour (Gómez-Baggethun et al., 2009). The market logic also changes human relationships with non-human nature (Sullivan and Hannis, 2015).

Measuring biodiversity is complex, as developing valuation methods for biodiversity and establishing exchange rules is technically difficult (Walker et al., 2009). BO policy documents often emphasise that the mitigation hierarchy (Avoidance, Minimising, Restoring on-site, and finally Compensating elsewhere) must be applied but in reality, adherence to the mitigation hierarchy has been difficult to ensure because the first three steps tend to be overlooked (Kiesecker et al., 2010; Hough and Robertson, 2009). The risk of creating a ‘license-to-trash’, additionally, and ‘biodiversity leakage’ are elements of BO that are often problematic to account for (Koh et al., 2017; Pilgrim and Bennun, 2014). Furthermore, civil society organisations argue that BO poses social risks. Communities may lose access to nature and livelihoods if biodiversity losses in one place are compensated somewhere further away, or if access to compensation land becomes restricted (FERN, 2014; Ituarte-Lima et al., 2014; FPP, 2011).

These challenges for valuation, institutional design and social risks are important to recognise but should not only be attributed to BO as they reflect the complexity of biodiversity conservation. For example, the governance capacity for managing BO often requires that environmental impact assessments, which examine the first three steps of the mitigation hierarchy, work well (Koh et al., 2017). Economic decisions taken daily implicitly value ecosystem services, often ascribing zero or wholly inadequate values to them (Pritchard Jr. et al., 2000) and prioritizing land uses that contribute the most to economic development. BO internalises conservation costs into development projects, thereby discouraging development of valuable green areas as they would be costlier to compensate (Levrel et al., 2017). Deciding the scope and limits of BO is a political question regarding the type of institutional arrangements that societies choose to adopt for governing the environmental commons (Gómez-Baggethun and Muradian, 2015).

Taking these concerns into account, we note that a clarification of the institutional diversity of BO policies is needed as BO are commonly represented as “market-based instruments”. We argue that this term is confusing because BO policies do not always involve market-like transactions and are not always primarily organised according to market or economic principles (Hrabanski, 2015; Lapeyre et al., 2015; Pirard, 2012). The literature often lacks an empirical understanding of the diverse ways that BO policies function (for some notable exceptions, see Wende et al., 2018; Vaissière and Levrel, 2015; Koh et al., 2014; Eftec et al., 2010). However, unlike the literature on the role of markets in payments for ecosystem services (Hahn et al., 2015; Vatn, 2015; Fletcher and Breiting, 2012), there is little scientific literature analysing whether existing BO policies are market-like (based on the market logic), or if they are more like government regulations defining liability rules. The purpose of this paper is to empirically fill this gap through a comparative analysis of six diverse BO policies from the global North and South.

The paper is structured as follows. First, we theorised the (in)commensurability of nature. Second, we constructed a typology of BO policies based on their central organizing mechanism for transaction and characterise each ideal type's defining properties. Third, we used these properties to frame our investigation of how the compensation stage

(the last step of the mitigation hierarchy) of BO policies are designed and implemented in relation to market-based principles. We examined the compensation process in six diverse BO policies through identifying the actors and institutions involved, and how they framed the decision-making procedure for compensating biodiversity losses. We focused on institutions, as these are the mechanisms by which social groups deal with value incommensurability and the social conflicts it often leads to (Boonstra, 2006; Pennings et al., 1999). Fourth, we synthesised our results of the six BO policies to see how they fit the ideal types and discussed the interactions between each type. Finally, we concluded by identifying challenges that arise in the compensation process and how the institutional arrangements can provide safeguards.

## 2. Theoretical framework and methods

### 2.1. Commensurability of nature

The act of commensuration involves transforming different qualities into a common metric to enable comparison (Espeland and Stevens, 1998). Commensuration of nature is based on the perception that the values we attribute to nature can be represent as capital, i.e. ‘natural capital’ (Costanza et al., 1997). In environmental economics, the standard case of commensuration is a cost-benefit analysis where different ecosystem services are measured with a monetary value. Sustaining the total sum of capital with full substitutability (commensurability) among different capital types is often referred to as “weak sustainability”, while the notion that natural capital should be sustained but with partial or no substitutability is referred to as the “strong sustainability” definition (Daly, 1990).

Various modes of (in)commensurability result from a process of institutionalisation. Through institutionalisation, norms or rules (both formal and informal) are established that can define and outline the domains of incompatible values. With boundaries in place that demarcate where incommensurability ends and commensurability begins, potential conflicts over practical implementation can be mediated and a trade-off reached. Institutions – norms and rules – in doing so provide ready-made or tested solutions (Boonstra, 2006; Cohen and Ben-Ari, 1993). Commensuration becomes possible and routine through this process of institutionalisation. Institutionalisation is thus an important imperative for social action, because it facilitates people's ability to deal routinely with otherwise complex moral dilemmas, and establishes a reproduction and continuation of society (Giddens, 1984).

BO is based on the Developer-Pays Principle (Koh et al., 2017) that requires compensation of ecosystem functions via ecological restoration activities, unlike the Polluter-Pays Principle (OECD, 1972) that obliges monetary compensation for environmental degradation such as a pollution tax. “No net loss of biodiversity and ecosystem services” has become the international standard for BO policies (BBOP, 2012; European Commission, 2011; Eftec et al., 2010). Hence, BO is clearly an operationalisation of strong sustainability. The notion of strong sustainability in offsets (Vaissière et al., 2017) can be further unpacked and we do this by suggesting a spectrum of commensurability corresponding to sustainability. The four modes of commensurability are: *Full*, *Flexible*, *Restricted* and *No commensurability (Incommensurable)*, as seen in Fig. 1.

*Incommensurability of nature* refers to very strong sustainability, where nature is regarded as non-substitutable and cannot be perceived as capital. Habitat is protected from development activities, which is also noted during the “avoidance” step of the mitigation hierarchy.

*Restricted commensurability* refers to strong sustainability (high criteria), where distinct types of natural capital can be substituted only with equivalent natural capital. BO accepts commensurability only within biodiversity (No Net Loss of biodiversity), and not between biodiversity and, say, carbon dioxide. A certain habitat type can be replaced only by the same habitat type, as seen in policy documents that often recommend BO to be ‘like-for-like’ (e.g. Tucker et al., 2014;

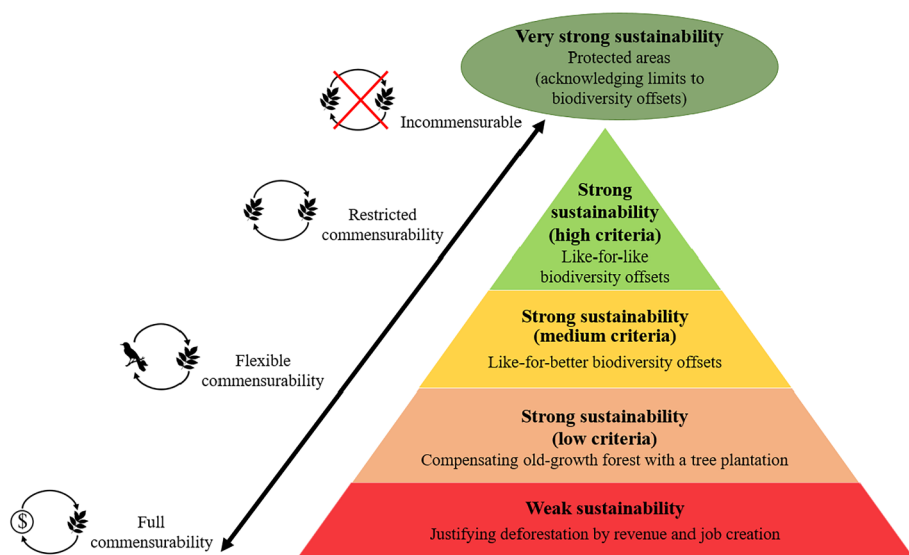


Fig. 1. The spectrum of commensurability of nature, with four modes corresponding to strengths of sustainability: Full, Flexible, Restricted and No commensurability (Incommensurable). Full commensurability relates to Weak sustainability, where natural capital is exchangeable with physical or financial capital. Flexible commensurability relates to Strong sustainability (low and medium criteria), where natural capital is exchangeable with other types of natural capital. Restricted commensurability relates to Strong sustainability (high criteria), where natural capital can only be exchanged with the same type of natural capital. Lastly, the incommensurability of nature relates to Very strong sustainability, where nature is regarded as irreplaceable.

BBOP, 2012).

*Flexible commensurability* consists of strong sustainability with both medium and low criteria. Strong sustainability (medium criteria) allows a habitat to be replaced by a different habitat that is considered to have a higher conservation priority ('like-for-better'). This allows the benefits of more threatened habitats to be conserved, but the difficulty lies in deciding how flexible the BO policy should be (Bull et al., 2015). In certain cases, a higher mode of commensurability may be beneficial for conservation ecology but commensurating across different habitat types requires policy-makers to establish clear exchange rules (e.g. habitat condition, area size, distance between impact and offset sites). Ideally, such rules for matching biodiversity losses and gains aim to capture the ecological integrity of an area. Habitat-function valuation methods often used in BO stem from existing conservation practices rooted in ecology, measuring habitat quality based on key characteristics of an ecosystem (Bull et al., 2015; Temple et al., 2012). Thus, methods used for BO are not vastly different from the methods used to prioritise among habitats when designating nature reserves.

By its design, BO only allows for flexible or restricted commensurability (high or medium criteria in Fig. 1) due to its 'like-for-like' and 'like-for-better' requirements. Replacing a biodiverse habitat with a tree plantation that increases carbon sequestration may be considered Strong sustainability with low criteria (Ekins, 2003), but to our knowledge this is not accepted by any BO policy.<sup>2</sup>

*Full commensurability* of nature refers to weak sustainability where natural capital is substitutable with other capital types such as financial or physical capital (Pearce and Atkinson, 1993). Commodification is therefore one dimension within full commensurability, but it does not represent the full spectrum of commensuration. The commodification of biodiversity and ecosystem services generally describes the expansion of market trade to previously non-marketed areas of the environment (Luck et al., 2012). For BO, commodification (marketization) mainly

refers to what extent conservation credits are traded on market conditions (Sullivan, 2013). In BO policies, the aspect of matching losses and gains is clearly separated from the aspect of how developers meet their requirement to pay for compensation. The degree of marketization results from the institutional design of a BO policy, which we empirically assess in this paper.

## 2.2. A typology to analyse BO policies

It is a conventional practice to understand modern societies as based on three basic institutional domains. Institutional arrangements are commonly distinguished pertaining to the domain of the *State*, *Market* and *Community* (Acheson, 1989; Wolfe, 1989; Streeck and Schmitter, 1985). Arts (1992) describes the *State* as the central coordination of a large number of actors making decisions for the collective good, a *Market* as competitive exchange relations between individual actors making independent decisions for mutual benefit, and *Community* as groups attempting to achieve communal objectives through voluntary cooperation and moral commitments.

These institutional domains should be understood as ideal-types, which are heuristic, analytical concepts that synthesize empirical attributes into an internally unified and logically rigorous typology (Swedberg, 2017; Weber, 2007 [1904], p. 211–215). As Boonstra and Nhung (2012) demonstrate, in the reality of natural resource management, each domain interacts with another in a dynamic interplay between the actors and their environment. They are not mutually exclusive either. Nevertheless, the use of these ideal-typical domains helps to understand the institutional diversity of BO policies and how they relate to various modes of commensuration, which are conventionally all rolled together under the term 'biodiversity offset'.

With a deductive reasoning approach using the ideal types described above, we developed a typology that describes the various mechanisms through which BO policies are realised: *Public Agency*, *Mandatory Market* and *Voluntary Offset* (Table 1). These ideal types relate to the guiding principle of interaction and allocation that characterises these institutions: *Public Agency* denotes the State's hierarchical control, *Mandatory Market* denotes the Market's dispersed competition and *Voluntary Offset* denotes the Community's spontaneous solidarity (Streeck and Schmitter, 1985). *Public Agency* and *Mandatory Market* are ideal types that stem from liability rules where the developer is legally required to conduct compensation, while *Voluntary Offset* describes the absence of such requirements but the developer compensates anyway.

In the case of intrusion on a public good like biodiversity, liability

<sup>2</sup> The commensurability of nature and its relation to sustainability in Fig. 1 can also be applied to carbon emissions. *Incommensurability* entails leaving fossil carbon in the ground. *Restricted commensurability* could be bio-energy with carbon capture and storage (BECCS), a mitigation technology that involves placing the carbon back into the ground. *Flexible commensurability* (strong sustainability, medium criteria) would be to compensate emissions of carbon dioxide with reduced emissions compared to a baseline from other greenhouse gases like methane, according to the averted loss logic. *Flexible commensurability* (strong sustainability, low criteria) allows compensating greenhouse gas emissions with afforestation or other land use, land-use change, and forestry (LU-LUCF) measures. Finally, paying a carbon tax exemplifies *Full commensurability*.

**Table 1**  
Properties defining biodiversity offset policy ideal types - ‘Public Agency’, ‘Mandatory Market’ and ‘Voluntary Offset’ (Inspired by Streeck and Schmitter, 1985).

Properties	Biodiversity offset policy ideal types		
	Public Agency	Mandatory Market	Voluntary Offset
1. Guiding principle of coordination and allocation	Legally mandatory, guided by bureaucratic order	Legally mandatory, guided by economic rationality and competition	Corporate social responsibility
2. Predominant, modal, collective actor	Municipalities and state agencies	Developers, environmental consultants, offset brokers, habitat banks, private landowners	Developers, non-governmental organisations
3. Principal medium of exchange	Coercion	Money	Reciprocity
4. Predominant resource	Consistency in procedures	Entrepreneurship	Developer's reputation and status
5. Principal decision-maker and rules	State conducts matching of impact and compensation	Developer's preference and cost-effectiveness	Developer decide the scope of compensation project
6. Predominant normative legal foundation	Producer liability	Producer liability and rules set for trading	Corporate social responsibility
7. Principal pay-offs and risks	Safeguarding equitable and predictable ecological and social outcomes. Risks legitimacy of top-down policies.	Cost-effective conservation. Risks being a ‘license-to-trash’.	Developers buy a ‘license to operate’. Risks being a ‘license-to-trash’ and perceived as greenwashing.

rules apply where the interfering party may be allowed to proceed but required to compensate for their actions (Bromley, 1991, p. 46). Within the context of BO, liability rules compel the project developer to compensate for their biodiversity losses by funding the cost of conservation actions either through the State or the Market.

The State has three main dimensions within environmental policies: a system of regulation, an administrative apparatus and a decision-making arena for environmental conflicts (Duit et al., 2016). Regulations, including defining property rights and rules for transactions, are part of both Public agency and Market ideal types. What is unique for the *Public Agency* type in BO is that a state agency makes decisions on the valuation and transaction, namely the matching between impact and compensation sites. The government plans, conducts and monitors the compensation project through its administrative agencies and the developer funds the costs.

A market is characterised by well-defined property rights and rules for competition (Samuels, 1989). The competition amongst buyers and sellers produces a price mechanism that mediates supply and demand (Randall, 1987). Hence, we define the *Mandatory Market* ideal type in BO as whether: 1) developers have the freedom of choice between several banks or landowners; and 2) the price of compensation is subject to competitive market forces. The government defines property rights, liabilities for developers, valuation metrics for biodiversity and sets exchange rules in trading biodiversity units (also known as credits). Mitigation banks or private compensation agencies identify willing landowners, conduct conservation actions, receive credits from a government agency and sell these credits to developers who are looking to fulfil their compensation requirements. A market exchange can also be driven by the developer seeking a landowner to contract without using biodiversity credits, which is the case in Sweden (Koh et al., 2017).

Within the *Voluntary Offset* type, there are no regulatory requirements or liabilities but developers fund compensation projects as a corporate social responsibility and risk management strategy. Conducting voluntary offsets enables companies to set a precedence on BO design and possibly influence emerging environmental legislation. This is mostly undertaken by extractive industries operating in the global South, who rely on technical guidance from external experts and environmental non-governmental organisations (NGOs) to facilitate the implementation. Moreover, showing concern for conservation helps companies obtain a ‘license-to-operate’ by: 1) gaining social acceptance with local communities and environmental groups; and 2) building regulatory goodwill for future development projects (Benabou, 2014). If the existence or promise of offsets increase the probability of authorities approving development projects (e.g. mining), this becomes a license-to-trash. Nevertheless, this risk also exists for mandatory offset policies.

### 2.3. Cross-case comparative analysis

A cross-case comparative analysis of environmental policies facilitates a generalization of experiences and trends across different cases, while providing an empirical base for a deeper understanding of a nation's political and socio-cultural context with its unique combination of actors and institutions. This approach aims to arrive at so-called ‘middle-range theory’ (Hedström and Udehn, 2009), which offers a “position between theoretical generalization and an appreciation for the importance of context” (Steinberg and VanDeveer, 2012, p. 9).

The selection of cases was influenced by data availability of policy documents, scientific papers, industry publications and grey literature of each BO case. Through case studies (Yin, 1994; Fidel, 1984), we examined the institutional arrangements of six (sub-)national BO policies in Australia, England, Germany, Madagascar, South Africa, and the US. US and Germany's compensation policies are well-established with over two decades of experience, Australia's policy has been in use for a decade, whilst England, South Africa and Madagascar's policies are currently in their pilot stages. Madagascar represents a voluntary project, whereas the other five countries have regulatory requirements for BO. Despite the difference in geographic regions, experience levels and jurisdiction, all these BO policies have comparable policy designs that coordinate institutions and actors to conduct the matching of biodiversity losses with conservation gains. We did not assess the actual performance outcomes of the policies because the focus is on their institutional designs. Together, these six case studies provide a substantial representation of the global diversity of institutional arrangements in BO policies.

## 3. Results

Guided by the properties in Table 1, we examined the institutional arrangements of BO policies by mapping their stakeholders and listing the decision-making process in a stepwise order, illustrated by Figs. 2–5, 7 and 8. Government actors are indicated by boxes without shading, Developers by crosshatched boxes, Private commercial entities by boxes with solid shading, and Public interest groups and local communities by dotted boxes.

### 3.1. United States: Wetland Mitigation Banking

Established as a national policy in 1980 under Section 404 of the Clean Water Act, the United States Environmental Protection Agency (US EPA) requires compensatory mitigation to be carried out by projects that will cause adverse impacts to wetlands. The goal is to achieve No Net Loss of wetland acreage and function (US EPA, 2008). There are three mechanisms for providing compensation, listed in order of

**United States: Wetland Mitigation Banking**

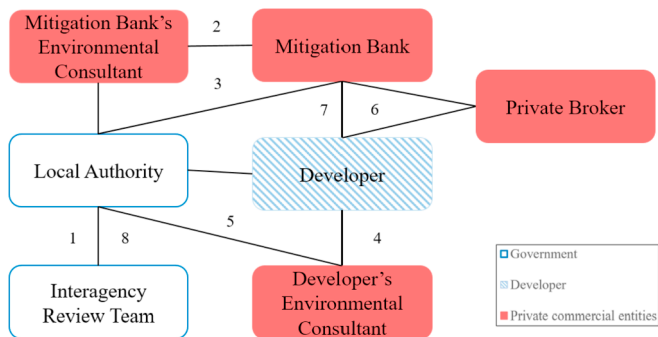


Fig. 2. Stakeholder mapping of the United States Wetland Mitigation Banking process. The numbers correspond to the steps below.

preference as established by the regulations: mitigation banks, in-lieu fee programs and permittee-responsible mitigation. We focused on mitigation banking, as it is prioritised by the US EPA and the most widely used. Mitigation banks either buy land or contract landowners, in order to conduct wetland restoration. For this, they receive wetland credits that can be sold according to the following steps in Fig. 2.

Step 1: The Interagency Review Team consists of experts at a federal or state level (e.g. US Fish and Wildlife Service, Water Management District, US Army Corps of Engineers) who have jurisdiction or an advisory role on the banking operations. The Interagency Review Team works with the local state authority to decide the rules of trading (i.e. geographic limits, type of credits, assessment methods, credit release schedule). There is no fixed ecological assessment method, but one of the most widely used methods is the Uniform Mitigation Assessment Methodology with 8 types of wetland credits spanning freshwater or coastal locations (Vaissière et al., 2017). The aim is to compensate for development impacts by restoring nearby, similar wetlands.

Step 2: There are two main types of mitigation banks, private banks and public/private banks. Private banks gather private actors that own and manage the bank. Public/private banks consist of a partnership between a public entity (state or county) that owns the land and a private entity that runs implements and manages the bank (Vaissière and Levrel, 2015). The mitigation bank acquires rights to land, either by buying land outright or purchasing easements. The bank hires environmental consultants to develop a proposed design for restoration activities as well as quantify the number and type of credits created.

Step 3: The mitigation bank then submits the proposed restoration design to the local authorities. The authorities review the proposal. The supply of credits is negotiated between the regulators and mitigation bank's environmental consultant. Restoration begins and credits are registered for sale on an online database.

Step 4: The developer hires an external environmental consultant to assess the quantity and quality of wetland losses at impact site.

Step 5: The consultant proposes the number and type of credits needed to offset the wetland losses, this is then reviewed by the local authority.

Step 6: Depending on the geographic service area and type of wetland credits available, the developer chooses a mitigation bank. Credit prices are negotiated between the mitigation bank and developer, with the help of a broker. There are a few brokers covering a large number of banks and they have a key role in stabilizing credit prices. Prices are influenced by the scarcity of the credit type and its potential demand in a given area, providing a financial incentive for the wetland banks. For example, the mitigation bankers in Florida are estimated to make a 10–15% return within 5–6 years (Vaissière and Levrel, 2015).

Step 7: Developer buys credits from mitigation bank. The mitigation bank's environmental consultant conducts monitoring of offset site, these reports are sent to the local authority following a schedule

throughout the lifetime of the mitigation bank.

Step 8: The bank reports to the local authority and Interagency Review Team.

**3.2. Australia: Biodiversity Offsets in New South Wales**

In New South Wales (NSW), Australia, offsetting legislation was first introduced in 2006 to address the clearing of native vegetation for urban developments and ensure 'No Net Loss of Biodiversity'. This was then updated in the 2016 Biodiversity Conservation Act to a dual system, both managed by the NSW Biodiversity Conservation Trust (BCT) that is a statutory not-for-profit government agency. The dual systems consist of: 1) the Biodiversity Offsets Scheme market approach (previously known as BioBanking), where the BCT assists private landowners who wish to sell biodiversity credits; and 2) the state-led Biodiversity Conservation Fund approach where the BCT secures offsets on behalf of developers that pay into the fund (similar to the US 'in-lieu' system) (BCT, 2016). Unlike the US wetland banking policy, there is only one public "bank" or market-place managed by the BCT. Since neither of these systems are prioritised in the policy, we describe both systems in the following steps in Fig. 3. The Biodiversity Offsets Scheme is noted from Step 1–8, while the Biodiversity Conservation Fund is noted from Step 1a-3a.

**Australia: Biodiversity Offsets in New South Wales**

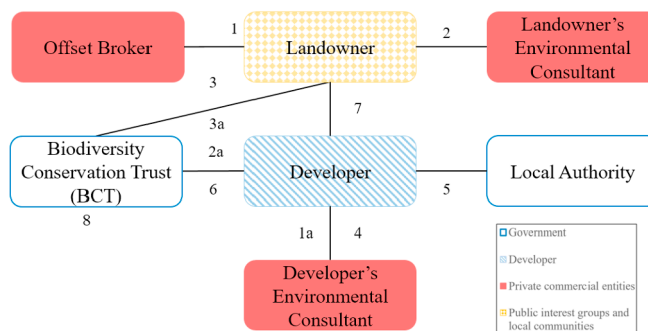


Fig. 3. Stakeholder mapping of the New South Wales Biodiversity Offsets dual systems. The Biodiversity Offsets Scheme process is Step 1–8, while the Biodiversity Conservation Fund is Step 1a-3a.

**3.2.1. Biodiversity Offsets Scheme**

Step 1: Landowners interested in setting up a compensation site can submit an 'expression of interest', where they identify the vegetation type and estimated area of their land. This is listed on the Biodiversity Credits Registry administered by the BCT, which allows the landowner to test demand for expected credits and find a potential buyer before formally entering a biodiversity stewardship agreement.

Step 2: If there is an interested buyer for those type of potential credits, the landowner hires an accredited environmental consultant (i.e. Biodiversity Assessment Method Assessors) to apply the Biodiversity Assessment Method and identify the exact number and type of credits that will be generated on their land. There are two types of credits: ecosystem (native vegetation) and species (flora/fauna) credits. The assessment method is established by the NSW Government; considering the site's context, condition of native vegetation and habitat suitability for threatened species.

Step 3: To establish a compensation site, the landowner submits an application to be an offset provider to the BCT. A broker may be able to assist with the application, which includes a 20-year management plan and estimating costs of management actions. When the proposed management plan and number of credits are approved by the BCT, the landowner enters a Biodiversity Stewardship agreement in perpetuity. The land is now available for offsetting with its credits for sale via the public registry.

Step 4: If a project exceeds certain area-clearing thresholds for native vegetation in a project development application, the developer may be required to conduct biodiversity offsetting. The developer, in this case, hires an accredited environmental consultant to apply the Biodiversity Assessment Method that quantifies the potential losses at the impact site. The developer's consultant calculates the number and type of ecosystem/species credits required to offset residual impacts.

Step 5: With the biodiversity losses quantified, the developer submits a project application to the local authority for planning permission. The local authority reviews the application and decides whether to approve or reject it. If the residual losses are deemed significant, the local authority reviews the offset credit requirements, i.e. the demand for credits.

Step 6: The developer can advertise for credits they need online via the public 'Credits Wanted' registry, administrated by the BCT, or search the registry for suitable credits offered from a landowner and buy them to fulfil its offset obligations. A broker can assist with locating like-for-like credits in the registry and contacting landowners who may be able to generate the relevant credits.

Step 7: The landowner can sell their credits to an interested developer. The landowner's consultant can assist with determining the credit prices, which are based on the opportunity cost of the land, management actions and profit margin. The credit price is then negotiated between the landowner and developer. After the credits are sold, the landowner carries out management actions and receives annual payments over a 20-year period.

Step 8: BCT conducts long-term monitoring of the offset site.

### 3.2.2. Biodiversity Conservation Fund

Step 1a: The developer hires an environmental consultant to quantify the number and type of credits required to offset from the impact site. The consultant then applies the Biodiversity Offsets Payment Calculator, established by the NSW Government. The credit price is calculated from: 1) the predicted market price for the credit type based on previous trades; 2) a risk premium; and 3) administration costs.

Step 2a: BCT reviews the calculation and once approved, the developer then transfers the amount required into the Biodiversity Conservation Fund.

Step 3a: Upon transfer, the developer passes their offsetting obligation to the BCT, who is then responsible for identifying equivalent credits and negotiating prices with landowners (doing the "matching").

### 3.3. Germany: Compensation Pools and Eco-accounts

In 1976, the German Federal Nature Conservation Act introduced the Impact Mitigation Regulation "Eingriffsregelung" as a national compensation policy from development impacts. The regulations state that "The intervening party shall be obligated to primarily endeavour to offset any unavoidable impairment through measures of nature conservation and landscape management, or to offset them in some other way" (Eftec et al., 2010, p. 63). Compensation is required for interventions on land use changes and ecosystem functions, except for the impacts of agriculture, forestry and fishing (Eftec et al., 2010, p. 188). Each state then develops its own regulations and guidelines to safeguard the procedural and ecological qualities of compensation measures (Wende et al., 2018, p. 137).

According to the relevant state regulations, local municipalities measure losses and conduct compensation. The German planning system distinguishes two zones: urban and rural. In urban or human settlement zones, compensation requirements are set out by the Building Code. This is often led by the municipality as both the developer and offset provider (Underwood et al., 2014). Most small-to-medium scale impacts in urban zones are addressed by municipal or regional compensation pools, while large-scale impacts in rural zones are handled by the state or accredited private agencies (Tucker et al.,

2014). These private agencies provide habitat banking services such as procuring land, long-term monitoring and management of compensation sites. The German Federal Association of Compensation Agencies has been active since 2006 in coordinating compensation agencies, issuing quality standards to ensure compliance and safeguard measures over the long-term (Wende et al., 2018). Due to limited data being available on compensation in rural zones, the following steps in Fig. 4 only describe the process for urban areas.

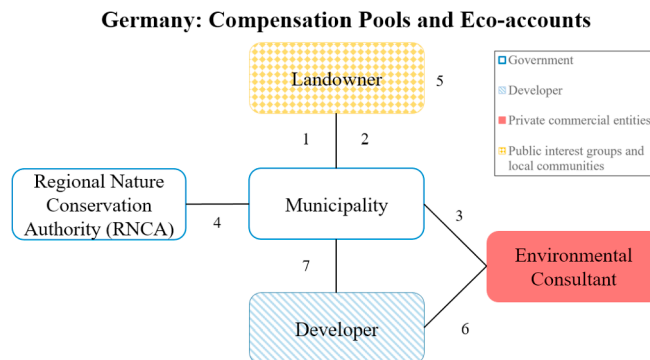


Fig. 4. Stakeholder mapping of the urban compensation process in Germany. The numbers correspond to the steps below.

Step 1: The municipality identifies suitable sites to build a 'compensation pool', based on local spatial planning maps. A pool is a mapped-out collection and concentration of usable sites for compensation purposes (Underwood et al., 2014).

Step 2: The ecological improvement potential of land is assessed by the municipality. If the potential is favourable, access to land is negotiated with landowners. There is often political reluctance to buy agricultural land for creating compensation pools so instead the municipality leases land from the private landowner and undertakes restoration measures (Rayment et al., 2014).

Step 3: The municipality plans compensation measures and quantifies the biodiversity gains in eco-points, possibly via an environmental consultant. There are over 40 different biodiversity evaluation methods in Germany and each municipality has freedom to choose which one it will use. These numerous approaches allow for capturing the unique ecological features of each region, but also pose a challenge in determining cumulative compensation outcomes on a national scale (Wende et al., 2018).

Step 4: The Regional Nature Conservation Authority (RNCA) evaluates the municipality's assessment of compensation measures and eco-point valuation (Underwood et al., 2014).

Step 5: Upon approval from the RNCA, the compensation measure is implemented, either by the municipality or contracted landowner. After completion, the eco-points are then registered and available for sale in the municipality's 'eco-account'.

Step 6: The developer can hire an environmental consultant to quantify biodiversity losses at the impact site into eco-points. These losses are then reviewed by the municipality.

Step 7: The municipality then matches the lost residual impacts points to gains in compensation measures points within the eco-account. 'Like-for-like' offsets in terms of ecosystem function are preferred (Tucker et al., 2014). The developer then pays for the costs of compensation, which are estimated according to a predefined list of standard conservation management measures and costs set by the municipality (Underwood et al., 2014).

### 3.4. England: Biodiversity Offsetting Pilots

In 2011, the Department for Environment and Rural Affairs (DEFRA) released its Biodiversity Strategy to 2020 that aims to achieve

‘No net loss of priority habitats’ (Baker et al., 2014a). Priority habitats have been identified as habitats that are most threatened and require conservation action. Voluntary offset projects have been piloted in six counties from 2012 to 2014 to test out DEFRA’s biodiversity unit valuation metric, but since these pilots have ended there has yet to be a decision on whether offsetting should be mandatory in England. The offsetting analysis is based on one pilot group, the Coventry, Solihull and Warwickshire pilot as this progressed the furthest amongst the six county pilots. This pilot group used a dual system where the developer can either: 1) use a biodiversity offsetting broker company or 2) choose an offsetting payment. Both approaches are described as follows in Fig. 5.

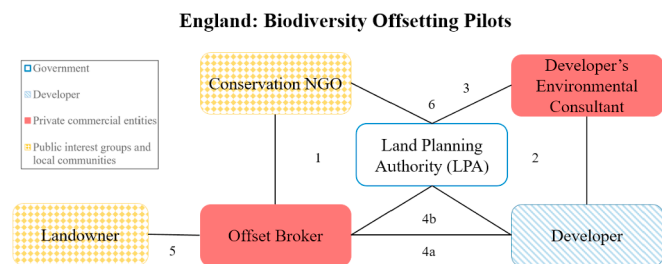


Fig. 5. Stakeholder mapping of the Coventry, Solihull and Warwickshire group in England’s biodiversity offsetting pilots. The numbers correspond to the steps below.

Step 1: An ecologist from the Land Planning Authority (LPA) holds a leading role in decision-making and ecological expertise, in partnership with an Offset Broker (i.e. the Environment Bank). The pilot groups are supported by stakeholders from environmental NGOs, who provide a forum for discussion on issues within the biodiversity offsetting strategy such as metric application, offset location and management activities. For example, a wildlife conservation NGO (Bat Conservation Trust) in the Devon pilot group advised on how biodiversity offsets could be implemented for the benefit of bat species (Baker et al., 2014b, p. 37). Environmental NGOs with land reserves are also involved as a potential provider of offset sites.

Step 2: For developments requiring an environmental impact assessment, the LPA obliges the developer, who hires ecological consultants or an environmental broker, to use the DEFRA metric to quantify biodiversity losses from the impact site (see Fig. 6). First, the

There is yet to be a standard habitat condition assessment tool, but the Common Standards Monitoring method is widely used (DEFRA (Department for EnvironmentFood and Rural Affairs), 2012). The habitat distinctiveness and condition is then combined to give an overall score in biodiversity units per hectare. Habitats of high distinctiveness should be compensated ‘like-for-like’ (e.g. woodland for woodland), whereas ‘like-for-better’ matching is allowed for habitats of low and medium distinctiveness (e.g. low bracken for medium grassland or high woodland).

Step 3: The LPA’s ecologists review the biodiversity losses reported by the developer’s environmental consultant. If significant residual loss is identified by the LPA, the developer is required to offset. The dual system enables the developer to choose between using a broker or opting for an offsetting payment.

Step 4a: In the Offset Broker approach, the developer can hire a biodiversity offsetting broker company to find an approved offsetting provider and suggest a management scheme with suitable ecological values. Once the offset site location is approved by the LPA, the broker draws up legal agreements with the developer for purchasing credits and the chosen landowner for management activities. The broker assists the landowner with determining credit prices, which reflects the costs of long-term management activities for subsequent biodiversity gains.

Step 4b: In the Offsetting Payment approach, the developer can choose to transfer an offset payment into a fund that is managed by the LPA. The LPA calculates the payment based on management costs per hectare as well as legal and administration fees. The LPA and the Environment Bank then collaborate to find a suitable offset based on strategic location identified in the sub-region’s green infrastructure strategy.

In both approaches, the offset broker is the same private company that has pooled willing landowners as compensation providers with a proposed management plan and estimated credit prices. The state-led approach was more commonly used in the pilot due to a limited supply of offset providers (Baker et al., 2014b, p. 21). The LPA reviews the transaction in both approaches and consults on the offset site location.

Step 5: The landowner then conducts management activities. In order to develop feasible management plans, the average period for an offset agreement is set to 30 years to be paid out from a fund managed by the LPA (Baker et al., 2014a, p. 28).

Step 6: The LPA monitors the offset site.

3.5. South Africa: Biodiversity Offsets in the Western Cape Province

Offsets have been introduced in South Africa as a way to finance protection of threatened habitats and the focus is therefore averted loss rather than restoration. A draft national policy was produced in 2012 but it has yet to be formally endorsed (Brownlie et al., 2017). Further guidelines have been published for two of South Africa’s nine provinces although their formalisation is on hold, pending clarity with the national position. The Western Cape Province was the first province to develop offset guidelines and is often used to inform governance discussions (Lukey et al., 2017). Their provincial guideline requires compensation of “residual impacts on biodiversity and ecosystem services that are of moderate to high significance” (DEA&DP, 2007, p. 2). Acknowledging that an absolute no net loss of biodiversity is “unlikely to be realistic in a developing country such as South Africa”, the policy aims to ensure that offset requirements are attached to certain amount of ‘acceptable loss’ of threatened vegetation types and ecosystem services (DEA&DP, 2007, p. 9). Based on the draft provincial guidelines of the Western Cape, the biodiversity offsetting process in South Africa is organised as follows in Fig. 7.

		Habitat distinctiveness		
		Low (2)	Medium (4)	High (6)
Condition	Good (3)	6	12	18
	Moderate (2)	4	8	12
	Poor (1)	2	4	6

Fig. 6. DEFRA’s metric where condition and distinctiveness are combined to determine the value of biodiversity units per hectare. Source: DEFRA (Department for EnvironmentFood and Rural Affairs), 2012.

impacted habitat type is identified from the UK Biodiversity Action Plan’s list of priority habitats (e.g. grassland, woodland, lowland heath). Next, the metric identifies the habitat’s distinctiveness based on a pre-defined list by DEFRA that considers parameters such as species richness, diversity and rarity. Lastly, the habitat’s condition is assessed.

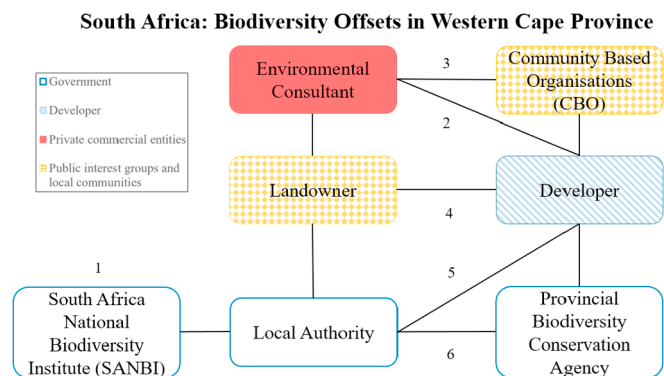


Fig. 7. Stakeholder mapping of biodiversity offsetting in the Western Cape Province, South Africa. The numbers correspond to the steps below.

Step 1: The South African National Biodiversity Institute (SANBI) is an autonomous, state-supported organisation that researches, monitors and reports on the state of biodiversity in South Africa. SANBI conducts a national biodiversity assessment and identifies ‘offset receiving areas’, which are priority areas for biodiversity conservation and represent the most efficient configuration in the landscape to protect regional biodiversity.

Step 2: As part of the environmental impact assessment, the developer hires an environmental consultant/biodiversity specialist to quantify biodiversity losses. The consultant investigates the anticipated biodiversity impacts based on indicators such as habitat type, species, ecosystem service and connectivity. The local authority reviews the biodiversity impacts and determines whether offsets are required. If yes, the consultant calculates offset requirements using a ‘basic offset ratio’ linked to the threat status of the affected ecosystem. The more threatened the ecosystem, the greater ratio is needed (e.g. 5:1 ratio for vulnerable ecosystems, 20:1 ratio for endangered ecosystems). With the offset ratio identified, potential site locations and management proposals are investigated.

Step 3: Key stakeholders (authorities, conservation agencies, farmers’ associations and other community-based organisations) consult on the design and location of offsets, preferably in an ‘offset receiving area’ (Jenner and Balmforth, 2015).

Step 4: With a willing offset provider found, the developer explores opportunities for creating a stewardship agreement with a landowner. Alternatively, the developer can purchase the land and donate it to a conservation agency for management in perpetuity. Finding willing offset providers in South Africa has been especially difficult as 70% of all land is privately owned (Brownlie et al., 2017). Lengthy negotiations between landowners and developer have led to significant time delays between the development impact and offset delivery, even up to several years.

Step 5: Developer submits the development project application and offset project proposal to the local authority, who consults the Provincial Biodiversity Conservation Agency (CapeNature) on suitability of the offset proposal in compensating for negative impacts (Brownlie et al., 2017). The offset proposal must report the social equity effects of the offset, in terms of who would benefit from and who would bear the cost of the offset. If the offset project proposal is found to be acceptable, permission for the development project is granted with the offset included as a condition of authorization.

Step 6: The developer pays the offset costs. Management and monitoring of the offset site is then passed on to the conservation agency, who reports back to the local authority. Every three years, the local authority evaluates the performance of offset projects (Republic of South Africa, 2017).

### 3.6. Madagascar: Rio Tinto QMM offset

Rio Tinto QIT Madagascar Minerals (RTQMM), a British-Australian-Malagasy mining company, is involved in the mining of ilmenite in Madagascar. There are no explicit national regulatory requirements for compensation (Huff, 2017). In 2004, RTQMM set its own corporate

environmental goal of ‘Net Positive Impact on biodiversity’. The goal is to achieve a Net Gain of littoral forest and high priority species by 2065, which is the anticipated date of mine closure (Temple et al., 2012). The following steps in Fig. 8 describes how RTQMM has used BO to compensate for the environmental impact of its mining activities.

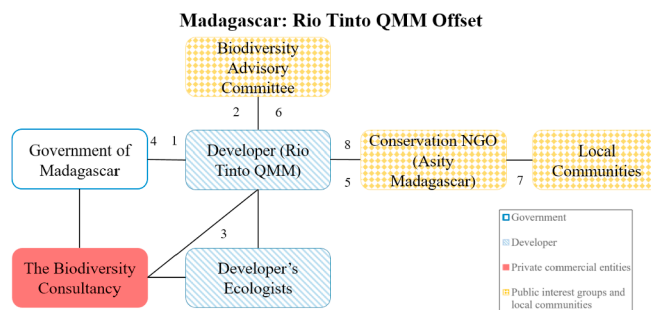


Fig. 8. Stakeholder mapping of the RTQMM offset in Madagascar. The numbers correspond to the steps below.

Step 1: RTQMM sets a ‘Net Positive Impact’ on biodiversity as its own corporate environmental goal for their ilmenite mining site in southeast Madagascar. The mine is estimated to have a direct impact on 6000 ha over its lifetime and consists of three sites: Mandena, Petriky and Sainte Luce.

Step 2: A group of biodiversity experts are assembled to form a Biodiversity Advisory Committee that reviews the developer’s biodiversity strategy and conservation measures. The committee comprises of experts from Fauna and Flora International, the Wildlife Conservation Society, IUCN and Hamburg University amongst others. “The Committee operates with full autonomy, being free to publically criticise RTQMM, and receives no remuneration for time spent on Committee meetings” (Temple et al., 2012, p. 61).

Step 3: Developer’s ecologists and hired environmental consultants (The Biodiversity Consultancy) investigate biodiversity losses by identifying impacted habitats and species, deciding upon a ‘Quality Hectares’ metric for habitats and developing their own ‘Units of Global Distribution’ metric for species. Habitat losses are then quantified.

Step 4: With input from the government and biodiversity experts, three offset sites of averted loss are identified in the region: Sainte Luce Forests (500 ha), Mahabo (1500 ha) and Bemangidy (4000 ha). Sainte Luce and Mahabo are like-for-like (littoral forest) and Bemangidy is like-for-not-like (lowland humid forest) (Bidaud et al., 2015).

Step 5: Developer partners with environmental NGO (Asity Madagascar) to develop long-term management plans for offset sites.

Step 6: The Biodiversity Advisory Committee provides guidance on the biodiversity valuation metrics and offset management plans.

Step 7: After consulting with the committee on the offset plan, the developer finances the offset project. The environmental NGOs collaborate with local communities to develop a long-term management plan for the forest and implement a community-based conservation project in the Bemangidy offset site, which is located within the protected Tsitongambarika forest (Temple et al., 2012). In collaboration with the Government of Madagascar, some of the offset sites have been incorporated within protected areas “to obtain sufficient gains in natural forest cover and conservation of priority species” (RTQMM, 2016, p. 15).

Step 8: A significant proportion of biodiversity gains are obtained by averted loss. The developer monitors and documents the rates of forest loss occurring across the mining lease sites and offset sites to credibly show that averted loss is achieved by mine closure in 2065.

### 3.7. Summary of BO policy ideal types

The six BO policies examined are analysed in Table 2, according to the properties defining the BO ideal types. The match of each BO policy with the ideal types is plotted into the Venn diagram in Fig. 9.



**Table 2**  
Summary of the six examined biodiversity offset policies' and how they perform in relation to the ideal types.

Biodiversity offset policy	Ideal types			Ideal type best fit	
	Public Agency	Mandatory Market	Voluntary Offset		
	<i>Does a state agency conduct matching of impact and compensation?</i>	<i>Can the developer choose freely between several compensation providers?</i>	<i>Is the price subject to market negotiation?</i>	<i>Does the developer offset voluntarily?</i>	
US, Wetland Mitigation Banking	No. Matching is done by developers and mitigation banks. However, the State negotiates credit supply and approves credit demand.	Partly. Developer can choose between several mitigation banks, but State restricts choice set.	Yes. Negotiation of market actors, assisted by broker.	No. State sets legal requirements for offsetting wetland impacts.	Mandatory Market
Australia, Biodiversity Offsets in New South Wales	No. Matching is done by developers and landowners. However, the State determines credit demand and approves credit calculations.	Partly. Developer can choose between several individual landowners, but State restricts choice set.	<i>Biodiversity Offsets Scheme.</i> Partly. Negotiation of market actors, assisted by broker and based on management costs plus profit.	<i>Biodiversity Offsets Scheme.</i> No. State sets legal requirements for offsetting native vegetation and species impacts.	Mandatory Market/ Public Agency
Germany, Compensation Pools & Eco-accounts	<i>Biodiversity Conservation Fund.</i> Yes. The state-run Biodiversity Conservation Trust (BCT) does the matching.	<i>Biodiversity Conservation Fund.</i> No. The developer pays to the BCT.	<i>Biodiversity Conservation Fund.</i> Partly. The developer pays into a fund, based on the estimated market price of a credit. BCT then negotiates price with landowner.	<i>Biodiversity Conservation Fund.</i> No. State sets legal requirements for offsetting native vegetation and species impacts.	Mandatory Market/ Public Agency
England, Biodiversity Offsetting Pilots	Yes. In urban areas, municipalities conduct the matching.	No. Municipality runs the compensation pool and sells eco-points to developers.	No. Pre-defined list of costs set by municipality.	No. State sets legal requirements for compensating development impacts.	Public Agency
	<i>Offset Broker.</i> Partly. The developer can choose but the Land Planning Authority (LPA) must approve compensation location.	<i>Offset Broker.</i> Partly. Developer can choose between several individual landowners, but State restricts choice set.	<i>Offset Broker.</i> No. Based on management costs set by landowner and broker.	<i>Offset Broker.</i> No. Guidelines released, national policy under discussion.	Public Agency/ Mandatory Market
South Africa, Biodiversity Offsets in Western Cape Province	<i>Offsetting Payment.</i> Yes. LPA selects a suitable offset.	<i>Offsetting Payment.</i> No. The developer pays into the Biodiversity Offsetting Bank.	<i>Offsetting Payment.</i> No. Based on estimates of management costs.	<i>Offsetting Payment.</i> No. Guidelines released, national policy under discussion.	Public Agency
Madagascar, RTQMM offset	Partly. The developer and state agency consult on compensation location.	No. Developer finds a landowner with help of stakeholders and offset receiving areas.	No. Developer establishes stewardship agreement with landowner.	No. Guidelines released, national policy under discussion.	Public Agency
	Partly. The developer and state agency consult on compensation location.	No. Developer found offset areas within their allotted mining areas or state-owned land.	No. Land access is obtained with government support.	Yes. Lack of legal requirements for compensation.	Voluntary Offset/ Public Agency

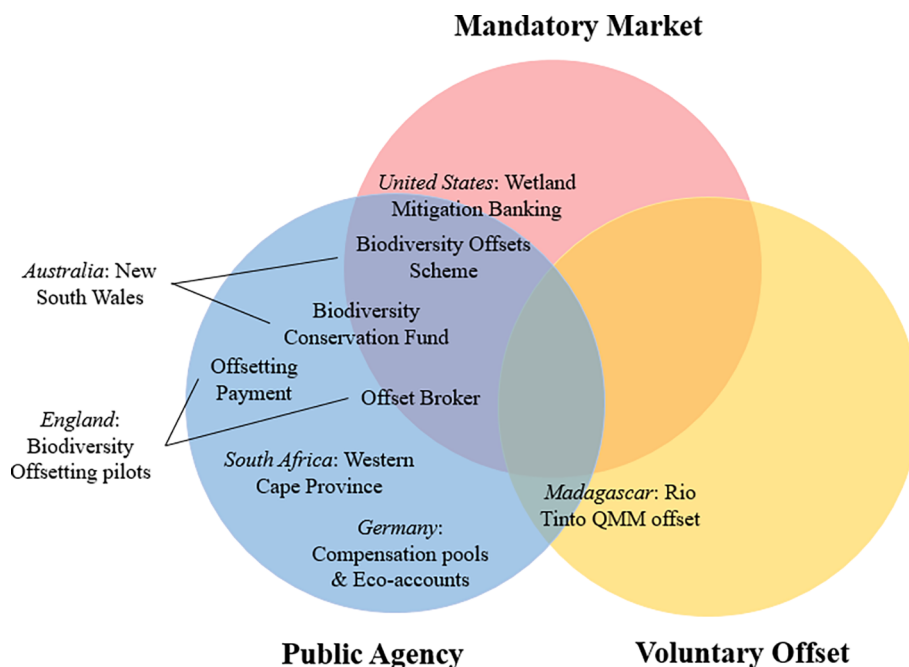


Fig. 9. Venn diagram of biodiversity offset policies and their ideal type interactions.

#### 4. Discussion

##### 4.1. Voluntary Offset: License-to-operate or greenwashing?

The RTQMM case has been noted as one of the first state-of-the-art voluntary compensation projects that engaged international experts to develop its own methodology for quantifying biodiversity values, thereby enhancing the company's image as a global leader in environmental sustainability for extractive industries (Bidaud et al., 2015). As seen in Fig. 9, the RTQMM case relates mostly to the *Voluntary Offset* ideal type, since there are currently no explicit offset requirements in Madagascar. This case sits also close to the *Public Agency* ideal type due to the involvement of the Malagasy government in locating some offset sites within existing protected areas, where RTQMM would then finance forest conservation activities. The government enables legal access to land, thereby granting formal legitimacy to the voluntary offset project. In lower-income countries, BO policies can provide an alternate source of conservation funding from the private sector.

However, RTQMM's application of their biodiversity valuation metric has been highly contested as it assumes a baseline of continued deforestation, where achieving No Net Loss at the project level means maintaining an annual forest loss rate of 0.9% per year (Virah-Sawmy et al., 2014). The offset project has also received criticisms with its impact on social equity. Land access conflicts have been noted between unresolved customary use rights of local farmers and formal state ownership claims. Within the impact area, communities were displaced from their homes, with research noting they were financially compensated below World Bank guidelines for involuntary resettlement (Seagle, 2012). Within the compensation area, exclusionary conservation approaches and land use restrictions threaten food security and livelihoods of communities living on or around the compensation sites (World Rainforest Movement, 2016). Due to the difficulties of developing a comprehensive biodiversity valuation metric that compensates for social and environmental losses, voluntary BO projects risk being perceived as greenwashing instead of a sign of corporate social responsibility.

##### 4.2. Public Agency: Integrating BO with conservation priorities

BO can be used to facilitate public biodiversity conservation priorities. Germany, South Africa and England have addressed this by incorporating strong state involvement in selecting the compensation site

location, hence their fit as a *Public Agency* ideal type. German municipalities identify suitable sites of ecological value and accumulate them for creating a compensation pool, the South African National Biodiversity Institute identifies priority conservation areas as offset receiving areas, while the English Offsetting Payment scheme specifically developed their BO policy as a delivery mechanism for the sub-region's green infrastructure planning. As identifying and gaining access to suitable land has been noted as a major challenge in operationalising compensation (Kiesecker et al., 2009), having a central agency that matches the impact and compensation site allows for broader landscape planning and opportunities for green infrastructure (Koh et al., 2017). The probability of securing viable ecological gains through offsetting are increased by supporting habitat connectivity and considering risks to long-term site maintenance (Kiesecker et al., 2010).

##### 4.3. Mandatory Market-Public Agency hybrids: The inevitable role of the State

Fig. 9 shows that there exists a gradient in *Mandatory Market-Public Agency* hybrid types with the US Wetland Mitigation Banking, Australian NSW BO Scheme and Conservation Fund as well as the English Offset Broker system. The US wetland banking fits mostly within the *Mandatory Market* type but also sits close to *Public Agency*, due to the strong state involvement in restricting developer's choices for offset to certain habitat types and localities. Vaissière and Levrel (2015) demonstrate how wetland banking is often misconstrued as a standard market, but actually represents a market-public agency hybrid where freedom of choice in a wetland bank is confined by regulations. Ecological factors are accounted for by regulators setting geographical trading limits and designating different types of wetland credits based on their biophysical nature (e.g. palustrine emergent credits, estuarine credits). Regulators determine the number of credits allocated to banks and required by developers to purchase.

In the theory section, we defined the *Mandatory Market* ideal type in terms of developers' freedom to choose a compensation provider and the price mechanism. The Australian NSW and English pilots combine dual systems and are therefore hybrids of *Mandatory Market* and *Public Agency* types. Our two criteria for a market reveals the hybridity of these systems. Firstly, the developer can either: 1) select a landowner to provide compensation influenced by the price signals of a credit (Australian Biodiversity

**Table 3**  
Hybrid BO policies on a scale from free market to government regulations: US Wetland mitigation banking and the dual systems of Australia and England.

	Criteria	Biodiversity Offset Policy				
		US, Wetland mitigation banking	Australia, Biodiversity Offsets Scheme	Australia, Biodiversity Conservation Fund	England, Offset broker	England, Offset payment
Free Market ↑	Developer has full freedom of choice in compensation provider	✗	✗	✗	✗	✗
	Market determines credit demand	✗	✗	✗	✗	✗
	Market negotiates credit supply	✗	✗	✗	✗	✗
Government Regulations ↓	The matching of biodiversity losses and gains is done by the developer	✓	✓	✗	✓	✗
	The (credit) price for compensation is negotiated by buyer and seller, not only based on cost estimates	✓	✓	✓	✗	✗

Offsets Scheme and English Offset Broker); or 2) within *Public Agency*, choose to calculate the costs of its credit obligations and transfer this into a fund run by the government that is responsible for matching the compensation (Australian Biodiversity Conservation Fund and English Offsetting Payment).

Secondly, price signals are apparent in the US and Australian NSW BO Scheme as the developer and compensation provider negotiate a suitable price with the aid of an intermediary. This is also the case in the NSW Biodiversity Conservation Fund because the developers pay an estimated cost of compensation to the BCT based on the predicted market price for the credit type from previous trades. Price negotiation still occurs between the BCT and the landowner. There is more room for price negotiation in the US wetland banking than the Australian NSW BO Scheme due to a larger market volume; there are 70 registered wetland banks in Florida alone (Vaissière and Levrel, 2015), while there is only one ‘bank’ in NSW run by the state agency BCT. Conversely, price signals play a limited role in both English systems since the price is a more objective estimate of management costs done by the landowner and broker.

Our results indicate that even in BO policies that best match the *Mandatory Market* type, ecological trading is very restricted and complex to carry out. All of these policies rely on consultants and brokers with considerable involvement of government agencies in determining, or at least approving, the supply and demand of credits. The government plays a vital role in establishing property rights, organizing biodiversity assessment methods and regulating transactions by reviewing each case of reported losses and gains.

#### 4.4. Commensurability versus commodification

We found that four cases (US, Australia, England and Germany) were strictly designed to favour restricted commensurability, through an expressed preference for like-for-like offsetting. In contrast, the BO policies of Madagascar and South Africa are more flexible (strong sustainability, medium criteria in Fig. 1), where like-for-better offsets were more commonly applied. South Africa explicitly favoured the averted loss principle, which is a variation of the like-for-better principle. Although this does not achieve No Net Loss at landscape level, averted loss can be justified by two arguments. First, in regions where large areas of high-conservation value are still not protected, it is more cost-effective to safeguard these areas rather than restoring degraded areas (Brownlie and Botha, 2009). Second, BO can be used primarily as a financial mechanism for funding protected areas in lower-income countries with limited public funds.

Our findings on commodification are more complex. Even for the BO policy that comes closest to the *Mandatory Market* type - the US Wetland Mitigation Banking - the developer's choice of compensation is severely restricted by government (credit/habitat type and geographic boundaries). There is no commodification in relation to commensurability: biodiversity

values are always replaced by and compared to similar biodiversity values. However, in BO policies with a strong market component, units of biodiversity (biodiversity credits) are assigned a monetary value and traded within market-like conditions. We found that this only occurs in the US and Australian BO Scheme. Hahn et al. (2015) refer to this as the 5th degree of commodification (out of six degrees), comparing BO to carbon markets and carbon offsets. The German, South African and English Offsetting payment cases belong to the 2nd degree of commodification, where government agencies do the matching of losses and gains, with no market trade of credits. Credits are not traded within the Australian NSW Biodiversity Conservation Fund, although this involves some market aspects, and the credit price is objectively estimated when trading credits within the English Offset Broker systems, so these two systems show intermediate degrees of commodification.

When aspects of both commensurability and commodification are taken into account, we find that none of the assessed BO policies are close to “free markets” (Table 3). Vatn (2015) refers to payments for ecosystem services schemes as ‘incomplete markets’ as they involve trade with a strong state involvement in setting up, approving and monitoring the transaction. This seems to be the case also for market-like BO policies.

The degree of commodification is independent of the mode of commensurability. Restricted commensurability can co-exist with a low degree of commodification, as illustrated by the German case. There is no role for price signals as the cost of compensation measures is determined by the municipalities with a pre-defined list of standard management measures and costs. On the contrary, restricted commensurability with a high degree of commodification is exemplified by the US case. Even if wetland credits are sold for dollars, this does not mean that the underlying biodiversity loss is commensurated through money. The biodiversity losses are only substitutable with similar biodiversity gains in wetland habitat types (see Fig. 1). Commodification does not necessarily require commensurability and vice versa.

With a high degree of commodification where the price of biodiversity credits is negotiated, there are incentives to both buyers and sellers to compromise the biodiversity quality that is traded (Vatn, 2015; Briggs et al., 2009; Kihlsinger, 2008). The developer is motivated to underestimate biodiversity losses, while the compensation provider is motivated to overestimate conservation gains. Since ecosystem values are complex with substantial information asymmetries and externalities in the trading process, BO market approaches need regulators to closely monitor transactions. The high ambition in the design of BO policies to restrict commensurability can only succeed if monitoring and enforcement are emphasised. The more a design of BO likens a free market, the more government capacity is needed for monitoring and enforcement (Vatn, 2018; Hahn et al., 2015; Glicksman and Kaime, 2013).

#### 4.5. Further research

The diversity illustrated by Fig. 9 would increase further if more cases are assessed. We do not aim to compile an exhaustive list of possible BO policy configurations in this paper, but rather provide a framing for understanding the empirical variety of institutional designs. For instance, an example of the *Mandatory Market/Voluntary Offset* intersection is the voluntary offset market being piloted in Chile with coastal industries (i.e. pulp mills, thermoelectric plants) considering compensating their marine impacts through an offset program managed by artisanal fishers who establish no-take zones within their fishing areas (Gelcich and Donlan, 2015).

Lastly, there are no reasons to believe a priori that market-based approaches lower transaction costs or are more efficient in other aspects. In the Australian cases, it has been reported that both the market-based and state-led approaches risk shifting biodiversity values from urban areas to less-populated, privately-managed areas (Hillman and Instone, 2010). Further research may address to what extent does the market degree of BO determine the social and ecological performance.

#### 5. Conclusion

We conclude that the characterisation of all biodiversity offset policies as 'markets for ecosystem services' is a misrepresentation. Our results suggest that even biodiversity offset policies that are often characterised as typical markets for ecosystem services are in fact very far from standard markets. Biodiversity offsets are based on the strong sustainability criterion and restricted commensurability, where losses in biodiversity values are compensated by similar types of biodiversity values. Just like the price of payment for ecosystem services is most often based on opportunity costs of conservation and not the ecosystem services provided, biodiversity offsetting does not imply putting a price tag on nature because the biodiversity value is expressed in biophysical, not monetary terms.

Rather, a diversity of institutional designs of biodiversity offset policies exists from strongly restricted markets for biodiversity to government-led liability procedures with no market aspects and purely voluntary offset policies. The state plays a key role in all offset policies, whether it is matching the biodiversity losses with gains, setting up trading rules or granting legitimacy to the compensation location. Governments considering to adopt biodiversity offsetting policies, as recommended by the *Convention on Biological Diversity*, can therefore design biodiversity offset policies with a high or low market involvement to match their political-economic culture.

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#### References

Acheson, J., 1989. Management of common property resources. In: Plattner, S. (Ed.), *Economic Anthropology*. Stanford University Press, Stanford, CA, pp. 351–378.

Alvarado-Quesada, I., Hein, L., Weikard, H.P., 2014. Market-based mechanisms for biodiversity conservation: a review of existing schemes and an outline for a global mechanism. *Biodivers. Conserv.* 23, 1–21. <https://doi.org/10.1007/s10531-013-0598-x>.

Arts, W., 1992. Community, market, and state: reflections on their potential for achieving economic justice. *Soc. Justice Res.* 5 (2), 137–152. <https://doi.org/10.1007/BF01048704>.

Baker, J., Sheate, W.R., Bennett, T., Payne, D., White, O., Forrest, S., 2014a. Volume 1: Final Report. WC1051: Evaluation of the Biodiversity Offsetting Pilot Programme DEFRA.

Baker, J., Sheate, W.R., Bennett, T., Payne, D., White, O., Forrest, S., 2014b. Volume 2: Pilot Reports WC1051: Evaluation of the Biodiversity Offsetting Pilot Programme DEFRA.

BBOP (Business and Biodiversity Offsets Programme), 2012. Standard on Biodiversity Offsets. BBOP, Washington, D.C. <http://bbop.forest-trends.org/guidelines/Standard.pdf>, Accessed date: 4 July 2018.

BCT (Biodiversity Conservation Trust), 2016. Biodiversity Offsets Program. <https://www.bct.nsw.gov.au/biodiversity-offsets-program>, Accessed date: 4 July 2018.

Benabou, S., 2014. Making up for lost nature? A critical review of the international development of voluntary biodiversity offsets. *Environ. Soc.* 5 (1), 103–123. <https://doi.org/10.3167/ares.2014.050107>.

Bennett, G., Gallant, M., Ten Kate, K., 2017. State of Biodiversity Mitigation 2017 Markets and Compensation for Global Infrastructure Development. *Forest Trends*. [https://www.forest-trends.org/wp-content/uploads/2018/01/doc\\_5707.pdf](https://www.forest-trends.org/wp-content/uploads/2018/01/doc_5707.pdf), Accessed date: 4 July 2018.

Bidaud, C., Hrabanski, M., Meral, P., 2015. Voluntary biodiversity offset strategies in Madagascar. *Ecosyst. Serv.* 15 (15), 181–189. <https://doi.org/10.3167/ares.2014.050107>.

Boonstra, W.J., 2006. Polder Limits. A Case Study of Value-conflicts on Dutch Rural Land Use. Ph.D. study. Wageningen University.

Boonstra, W.J., Nhung, P.T.H., 2012. The ghosts of fisheries management. *J. Nat. Resour. Pol. Res.* 4 (1), 1–25. <https://doi.org/10.1080/19390459.2012.642634>.

Briggs, B.D.J., Hill, D.A., Gillespie, R., 2009. Habitat banking—how it could work in the UK. *J. Nat. Conserv.* 17, 112–122. <https://doi.org/10.1016/j.jnc.2008.12.006>.

Bromley, D., 1991. *Environment and Economy: Property Rights and Public Policy*. Blackwell Publishers, Cambridge.

Brownlie, S., Botha, M., 2009. Biodiversity offsets: adding to the conservation estate, or "no net loss"? *Impact Assess. Proj. Apprais.* 27 (3), 227–231. <https://doi.org/10.3152/146155109X465968>.

Brownlie, S., von Hase, A., Botha, M., Manuel, J., Balmforth, Z., Jenner, N., 2017. Biodiversity offsets in South Africa – challenges and potential solutions. *Impact Assess. Proj. Apprais.* 35 (3), 248–256. <https://doi.org/10.1080/14615517.2017.1322810>.

Bull, J.W., Hardy, M.J., Moilanen, A., Gordon, A., 2015. Categories of flexibility in biodiversity offsetting, and their implications for conservation. *Biol. Conserv.* 192, 522–532. <https://doi.org/10.1016/j.biocon.2015.08.003>.

CBD (Convention on Biological Diversity), 2008. COP 9 Decision IX/11: Review of Implementation of Articles 20 and 21. <https://www.cbd.int/decision/cop/?id=11654>, Accessed date: 4 July 2018.

Cohen, E., Ben-Ari, E., 1993. Hard choices: a sociological perspective on value incommensurability\*. *Hum. Stud.* 16.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., 1997. The value of the world's ecosystem services and natural capital. *Nature* 387 (6630), 253.

Daly, H.E., 1990. Sustainable development: from concept and theory to operational principles. *Popul. Dev. Rev.* 16, 25–43.

DEA&DP (Department of Environmental Affairs and Development Planning), 2007. Provincial Guideline on Biodiversity Offsets. Republic of South Africa, Provincial Government of the Western Cape, Cape Town. [http://www.westerncape.gov.za/text/2007/3/pgwcoffsetsguidelinedraft\\_5march\\_07.pdf](http://www.westerncape.gov.za/text/2007/3/pgwcoffsetsguidelinedraft_5march_07.pdf), Accessed date: 4 July 2018.

DEFRA (Department for Environment, Food and Rural Affairs), 2012. Biodiversity Offsetting Pilots Technical Paper: the Metric for the Biodiversity Offsetting Pilot in England. <https://www.gov.uk/government/publications/technical-paper-the-metric-for-the-biodiversity-offsetting-pilot-in-england>, Accessed date: 4 July 2018.

Dempsey, J., Collard, R., 2017. If biodiversity offsets are a dead end for conservation, what is the live wire? A response to Apostolopoulou & Adams. *Oryx* 51 (1), 35–39. <https://doi.org/10.1017/S0030605316000752>.

Duit, A., Feindt, P.H., Meadowcroft, J., 2016. Greening Leviathan: the rise of the environmental state? *Environ. Polit.* 25 (1), 1–23. <https://doi.org/10.1080/09644016.2015.1085218>.

Eftcc, et al., 2010. The Use of Market-based Instruments for Biodiversity Protection - Habitat Banking- Appendix Case Studies. [http://ec.europa.eu/environment/enveco/pdf/eftec\\_habitat\\_case\\_study.pdf](http://ec.europa.eu/environment/enveco/pdf/eftec_habitat_case_study.pdf), Accessed date: 4 July 2018.

Ekens, P., 2003. Identifying critical natural capital: conclusions about critical natural capital. *Ecol. Econ.* 44 (2–3), 277–292.

Espeland, W.N., Stevens, M.L., 1998. Commensuration as a social process. *Annu. Rev. Sociol.* 24, 313–343.

European Commission, 2011. Our Life Insurance, Our Natural Capital: an EU Biodiversity Strategy to 2020. [http://ec.europa.eu/environment/nature/biodiversity/strategy/index\\_en.htm#stra](http://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm#stra), Accessed date: 4 July 2018.

FERN, 2014. What is biodiversity offsetting and why is it problematic? [http://fern.org/sites/fern.org/files/Biodiversity2\\_EN.pdf](http://fern.org/sites/fern.org/files/Biodiversity2_EN.pdf), Accessed date: 4 July 2018.

Fidel, R., 1984. The case study method: a case study. *Libr. Res.* 6 (3), 273–288.

Fletcher, R., Breitling, J., 2012. Market mechanism or subsidy in disguise? Governing payment for environmental services in Costa Rica. *Geoforum* 43, 402–411. <https://doi.org/10.1016/j.geoforum.2011.11.008>.

FPP (Forest Peoples Programme), 2011. Submission to the Convention on Biological Diversity Relating to Innovative Financial Mechanisms and the Rights of Indigenous Peoples and Local Communities. <https://www.cbd.int/financial/doc/fpp-innovative-financial-mechanisms-2011-en.pdf>, Accessed date: 4 July 2018.

Gelcich, S., Donlan, C.J., 2015. Incentivizing biodiversity conservation in artisanal fishing communities through territorial user rights and business model innovation. *Conserv. Biol.* 29 (4), 1076–1085. <https://doi.org/10.1111/cobi.12477>.

Giddens, A., 1984. *The Constitution of Society*. Polity Press, Cambridge.

Glicksman, R.L., Kaime, T., 2013. A comparative analysis of accountability mechanisms for ecosystem services markets in the United States and the European Union. *Transnatl. Environ. Law* 2, 259–283. <https://doi.org/10.1017/S2047102513000125>.

Gómez-Baggethun, E., Muradian, R., 2015. In markets we trust? Setting the boundaries of

- Market-Based Instruments in ecosystem services governance. *Ecol. Econ.* 117, 217–224. <https://doi.org/10.1016/j.ecolecon.2015.03.016>.
- Gómez-Baggethun, E., de Groot, R., Lomas, P.L., Montes, C., 2009. The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes. *Ecol. Econ.* 69 (6), 1209–1218. <https://doi.org/10.1016/j.ecolecon.2009.11.007>.
- Hahn, T., McDermott, C., Ituarte-Lima, C., Schultz, M., Green, T., Tuvendal, M., 2015. Purposes and degrees of commodification: economic instruments for biodiversity and ecosystem services need not rely on markets or monetary valuation. *Ecosyst. Serv.* 16, 74–82. <https://doi.org/10.1016/j.ecoser.2015.10.012>.
- Hedström, P., Udehn, L., 2009. Analytical sociology and theories of the middle range. In: Bearman, P., Hedström, P. (Eds.), *The Oxford Handbook of Analytical Sociology*. Oxford University Press, pp. 25–47.
- Hillman, M., Instone, L., 2010. Legislating nature for biodiversity offsets in New South Wales, Australia. *Soc. Cult. Geogr.* 11 (5), 411–431. <https://doi.org/10.1080/14649365.2010.488746>.
- Hirschman, A.O., 1986. *Rival Views of Market Society and Other Recent Essays*. Elisabeth Sifton Books: Viking, New York.
- Hough, P., Robertson, M., 2009. Mitigation under section 404 of the clean water act: where it comes from, what it means. *Wetl. Ecol. Manag.* 17, 15–33.
- Hrabanski, M., 2015. The biodiversity offsets as market-based instruments in global governance: origins, success and controversies. *Ecosyst. Serv.* 15, 143–151. <https://doi.org/10.1016/j.ecoser.2014.12.010>.
- Huff, A., 2017. Black sands, green plans and vernacular (in)securities in the contested margins of south-western Madagascar. *Peacebuilding* 5 (2), 153–169. <https://doi.org/10.1080/21647259.2016.1277012>.
- IFC (International Finance Corporation), 2012. Performance Standard 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources. [https://www.ifc.org/wps/connect/bff0a28049a790d6b835faa8c6a8312a/PS6\\_English\\_2012.pdf?MOD=AJPERES](https://www.ifc.org/wps/connect/bff0a28049a790d6b835faa8c6a8312a/PS6_English_2012.pdf?MOD=AJPERES), Accessed date: 4 July 2018.
- Ituarte-Lima, C., Schultz, M., Hahn, T., McDermott, C., Cornell, S., 2014. Biodiversity financing and safeguards: lessons learned and proposed guidelines. In: Information Document UNEP/CBD/COP/12/INF/27 for the 12th Conference of the Parties of the Convention on Biological Diversity in Pyeongchang Korea. SwedBio/Stockholm Resilience Centre at Stockholm University, Stockholm.
- Jenkins, M., Scherr, S.J., Inbar, M., 2004. Markets for biodiversity services: potential roles and challenges. *Environment* 46 (6), 32–42. <https://doi.org/10.1080/00139157.2004.10545160>.
- Jenner, N., Balmforth, Z., 2015. *Biodiversity Offsets: Lessons Learnt from Policy and Practice*. Country Summary Report: South Africa. Fauna & Flora International.
- Kiesecker, J.M., Copeland, H., Pocewicz, A., Nibbelink, N., Mckenney, B., Dahlke, J., Holloran, M., Stroud, D., 2009. A framework for implementing biodiversity offsets: selecting sites and determining scale. *BioScience* 59 (1), 77–84. <https://doi.org/10.1525/bio.2009.59.1.11>.
- Kiesecker, J.M., Copeland, H., Pocewicz, A., Mckenney, B., 2010. Development by design: blending landscape-level planning with the mitigation hierarchy. *Front. Ecol. Environ.* 8 (5), 261–266. <https://doi.org/10.1890/090005>.
- Kihlsinger, R.L., 2008. Success of wetland mitigation projects. *Natl. Wetl. Newsl.* 30 (2), 14–17.
- Koh, N.S., Hahn, T., Ituarte-Lima, C., 2014. A Comparative Analysis of Ecological Compensation Programs: The Effect of Program Design on the Social and Ecological Outcomes. Uppsala University.
- Koh, N.S., Hahn, T., Ituarte-Lima, C., 2017. Safeguards for enhancing ecological compensation in Sweden. *Land Use Policy* 64, 186–199. <https://doi.org/10.1016/j.landusepol.2017.02.035>.
- Lapeyre, R., Froger, G., Hrabanski, M., 2015. Biodiversity offsets as market-based instruments for ecosystem services? From discourses to practices. *Ecosyst. Serv.* 15, 125–133. <https://doi.org/10.1016/j.ecoser.2014.10.010>.
- Levrel, H., Scemama, P., Vaissière, A.C., 2017. Should we be wary of mitigation banking? evidence regarding the risks associated with this wetland offset arrangement in Florida. *Ecol. Econ.* 135, 136–149. <https://doi.org/10.1016/j.ecoser.2014.10.010>.
- Luck, G.W., Chan, K.M., Eser, U., Gómez-Baggethun, E., Matzdorf, B., Norton, B., Potschin, M.B., 2012. Ethical considerations in on-ground applications of the ecosystem services concept. *BioScience* 62, 1020–1029.
- Lukey, P., Cumming, T., Paras, S., Kubiszewski, I., Lloyd, S., 2017. Making biodiversity offsets work in South Africa – a governance perspective. *Ecosyst. Serv.* 27, 281–290. <https://doi.org/10.1016/j.ecoser.2017.05.001>.
- OECD (Organisation for Economic Co-operation and Development), 1972. *The Polluter Pays Principle*.
- Pearce, D.W., Atkinson, G.D., 1993. Capital theory and the measurement of sustainable development: an indicator of “weak” sustainability. *Ecol. Econ.* 8, 103–108.
- Penning, P., Keman, H., Kleijnijhuis, J., 1999. *Doing Research in Political Science. An Introduction to Comparative Methods and Statistics*. Sage Publications, London.
- Pilgrim, J.D., Bennun, L., 2014. Will biodiversity offsets save or sink protected areas? *Conserv. Lett.* 7 (5), 423–424. <https://doi.org/10.1111/conl.12145>.
- Pirard, R., 2012. Market-based instruments for biodiversity and ecosystem services: a lexicon. *Environ. Sci. Policy* 19–20, 59–68. <https://doi.org/10.1016/j.envsci.2012.02.001>.
- Pritchard Jr., L., Folke, C., Gunderson, L., 2000. Valuation of ecosystem services in institutional context. *Ecosystems* 3 (1), 36–40. <https://doi.org/10.1007/s100210000008>.
- Rainey, H.J., Pollard, E.H.B., Dutton, G., Ekstrom, J.M.M., Livingstone, S.R., Temple, H.J., Pilgrim, J.D., 2015. A review of corporate goals of No net loss and net positive impact on biodiversity. *Oryx* 49 (2), 232–238. <https://doi.org/10.1017/S0030605313001476>.
- Randall, A., 1987. *Resource Economics: An Economic Approach to Natural Resource and Environmental Policy*, second ed. John Wiley & Son, New York.
- Rayment, M., Haines, R., McNeil, D., Conway, M., Tucker, G., Underwood, E., 2014. *Study on Specific Design Elements of Biodiversity Offsets: Biodiversity Metrics & Mechanisms for Securing Long Term Conservation Benefits*. European Commission.
- Republic of South Africa, 2017. *Draft National Biodiversity Offset Policy*. [https://www.environment.gov.za/sites/default/files/legislations/nema107of1998\\_draftnationalbiodiversityoffsetpolicy\\_gn40733.pdf](https://www.environment.gov.za/sites/default/files/legislations/nema107of1998_draftnationalbiodiversityoffsetpolicy_gn40733.pdf), Accessed date: 4 July 2018.
- RTQMM (Rio Tinto QMM), 2016. *Biodiversity, Communities and Social Performance Multi Year Plan: 2016 – 2021*.
- Samuels, W.J., 1989. Legal-economic nexus. *George Wash. Law Rev.* 57 (6), 1556–1578.
- Seagle, C., 2012. Inverting the impacts: mining, conservation and sustainability claims near the Rio Tinto/QMM ilmenite mine in Southeast Madagascar. *J. Peasant Stud.* 39 (2), 447–477. <https://doi.org/10.1080/03066150.2012.671769>.
- Stavins, R., Whitehead, B., 1997. Market-based environmental policies. In: Chertow, M.R., Esty, D. (Eds.), *Thinking Ecologically: the Next Generation of Environmental Policy*. Yale University Press, U.S.
- Steinberg, P.F., VanDeveer, S., 2012. *Comparative Environmental Politics*. MIT Press, Cambridge, MA.
- Streeck, W., Schmitter, P.C., 1985. Governance to Social Order Community, Community, market, state- and associations? The prospective contribution of interest governance to social order. *Eur. Socio Rev.* 1 (2), 119–138.
- Sullivan, S., 2013. Banking nature? The spectacular financialisation of environmental conservation. *Antipode* 45 (1), 198–217. <https://doi.org/10.1111/j.1467-8330.2012.00989.x>.
- Sullivan, S., Hannis, M., 2015. Nets and frames, losses and gains: value struggles in engagements with biodiversity offsetting policy in England. *Ecosyst. Serv.* 15, 162–173. <https://doi.org/10.1016/j.ecoser.2015.01.009>.
- Swedberg, R., 2017. How to use Max Weber's ideal type in sociological analysis. *J. Classical Sociol.* 18 (3), 181–196.
- Temple, H.J., Anstee, S., Ekstrom, J., Pilgrim, J.D., Rabenantoandro, J., Ramanamanjato, J.-B., Randriatafika, F., Vincelette, M., 2012. *Forecasting the Path towards a Net Positive Impact on Biodiversity for Rio Tinto QMM*. IUCN and Rio Tinto Technical Series No.2. <https://portals.iucn.org/library/sites/library/files/documents/2012-049.pdf>, Accessed date: 4 July 2018.
- Tucker, G., Allen, B., Conway, M., Dickie, I., Hart, K., Rayment, M., Schulp, C., van Teeffelen, A., 2014. *Policy Options for an EU No Net Loss Initiative: Final Report-Annexes*. Institute for European Environmental Policy, London.
- Underwood, E., Wende, W., Stein, C., Tucker, G., 2014. *A Review of Recent Biodiversity Offsetting Practice in Germany*. DEFRA.
- US EPA (United States Environmental Protection Agency), 2008. *Compensatory Mitigation for Losses of Aquatic Resources; Final Rule*. U.S. Army Corps of Engineers, Department of Defense and Environmental Protection Agency. [https://www.epa.gov/sites/production/files/2015-03/documents/2008\\_04\\_10\\_wetlands\\_wetlands\\_mitigation\\_final\\_rule\\_4\\_10\\_08.pdf](https://www.epa.gov/sites/production/files/2015-03/documents/2008_04_10_wetlands_wetlands_mitigation_final_rule_4_10_08.pdf), Accessed date: 4 July 2018.
- Vaissière, A.C., Levrel, H., 2015. Corrigendum to Biodiversity offset markets: what are they really? An empirical approach to wetland mitigation banking. *Ecol. Econ.* 114, 242. <https://doi.org/10.1016/j.ecolecon.2015.01.002>.
- Vaissière, A.C., Levrel, H., Scemama, P., 2017. Biodiversity offsetting: clearing up misunderstandings between conservation and economics to take further action. *Biol. Conserv.* 206, 258–262. <https://doi.org/10.1016/j.biocon.2016.11.036>.
- Vatn, A., 2015. Markets in environmental governance. From theory to practice. *Ecol. Econ.* 117, 225–233. <https://doi.org/10.1016/j.ecolecon.2014.07.017>.
- Vatn, A., 2018. Environmental governance – from public to private? *Ecol. Econ.* 148, 170–177. <https://doi.org/10.1016/j.ecolecon.2018.01.010>.
- Virah-Sawmy, M., Ebeling, J., Taplin, R., 2014. Mining and biodiversity offsets: a transparent and science-based approach to measure no-net-loss. *J. Environ. Manag.* 143, 61–70. <https://doi.org/10.1016/j.jenvman.2014.03.027>.
- Walker, S., Brower, A.L., Stephens, R.T.T., Lee, W.G., 2009. Why bartering biodiversity fails. *Conserv. Lett.* 2 (4), 149–157. <https://doi.org/10.1111/j.1755-263X.2009.00061.x>.
- Weber, M., 2007. [1904] “Objectivity” in social science. In: Calhoun, C., Gerteis, J., Moody, J., Pfaff, S., Virk, I. (Eds.), *Classical Sociological Theory*. Blackwell Publishing, London, pp. 211–217.
- Wende, W., Tucker, G., Quéfier, F., Rayment, M., Darbi, M., 2018. *Biodiversity Offsets—the European Perspective on No Net Loss of Biodiversity and Ecosystem Services*. Springer International Publishing, Cham.
- Wolfe, A., 1989. Market, state, and society as codes of moral obligation. *Acta Sociol.* 32 (3), 221–236.
- World Bank, 2017. *The World Bank environmental and social framework*. <http://documents.worldbank.org/curated/en/383011492423734099/pdf/114278-WP-REVISED-PUBLIC-Environmental-and-Social-Framework.pdf>, Accessed date: 4 July 2018.
- World Rainforest Movement, 2016. *Rio Tinto's Biodiversity Offset in Madagascar: Double Landgrab in the Name of Biodiversity?* <https://wrm.org.uy/books-and-briefings/rio-tintos-biodiversity-offset-in-madagascar-double-landgrab-in-the-name-of-biodiversity/>, Accessed date: 4 July 2018.
- Yin, R., 1994. Discovering the future of the case study method in evaluation research. *Eval. Pract.* 15 (3), 283–290.