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Production-Integrated Compensation in Environmental Offsets—A Review of a German Offset Practice

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Abstract: Environmental offset schemes designed to compensate for adverse development impacts are found in countries worldwide, pursuing no-net-loss policy. In Germany, a practice combining environmental improvements with farming evolved in the early 2000s, known as production-integrated compensation (PIC) (Produktionsintegrierte Kompensation). This paper provides a review of PIC, presenting origins, legal and cost aspects, as well as examples of PIC practice. PIC key challenges are the complexity of environmental improvements of agrarian habitats and the high efforts for communication among diverse actors and for designing and monitoring PIC. Benefits for nature conservation lie in the protection of strongly endangered species and an increase of acceptance of compensation measures. Positive effects for farmers are the sustaining of arable farmland and involvement in setting up land management terms. Investors profit from the increased availability of sites. However, a specific legal framework for PIC is still developing and representation of PIC in offset registries in the German States is only very small. In conclusion, targeted design, continuous monitoring, and long-term financing provided, PIC may (a) increase offset efficiency by focusing on implementation while avoiding land purchase and physical investments and (b) increase offset effectiveness by high conservation benefits and a collaborative approach towards farmers.

Keywords: production-integrated compensation; impact mitigation regulation; no-net-loss; environmental offsets; biodiversity offsets; arable wild plants; Germany

1. Introduction

Human development activities have an impact on land in countries worldwide. To counterbalance the resulting harms, offset policies have come to be a global phenomenon [1]. Offset policies aim at environmental compensation like biodiversity, habitats, ecological functions, or carbon, but also to preserve agricultural land (e.g., References [2–7]).

Mechanisms and schemes of biodiversity offsetting are a common subject to research (see e.g., References [8–22]). Apart from positive experiences, evaluations document a variety of shortcomings, e.g., in terms of ecological effectiveness [23–29], monitoring and long-term management [10,24,26,30], functional appropriateness [31], acceptance and implications for farmers [32–36], availability of land [26,37], or the concept and implementation in general [38–43]. Some authors are challenging the fundamental principle of environmental offsetting on the grounds of political, ethical, ecological, and social aspects [44–52]. Awareness and sensitivity with regards to fundamental and far reaching implications by offset policies are necessary, however, given that human development activities are unlikely to cease and existing policies require offsets, this paper focuses on how to successfully realize offset policies for the time they persist. For this purpose, an innovative environmental

compensation practice from Germany is presented, the production-integrated compensation (PIC) (Produktionsintegrierte Kompensation PIK). Known in Germany, the PIC concept is barely described in international literature and is only briefly mentioned by some authors (short reference or description of the idea in References [35,53–57], related approaches are discussed in References [58–64]).

The paper addresses this gap by providing a review of PIC. The comprehensive outline offers the chance to transfer principles and practices of PIC to offset approaches in different settings and regions. It benefits investors and planners with new possibilities for offsets, especially for mitigation of conflicting claims of land use and compensation interests; equips authorities with information for project approval procedures; encourages farmers to become an active PIC supplier; and offers nature conservation actors grounds for environmental assessment of PIC. The presented alternative perspective on offsetting may be the basis for practitioners as well as for further theoretical discussion, aiming to tap into the potential of offset policies.

The following Section 2 provides the basics with a definition of PIC, tracing the origins and backgrounds from nature conservation as well as agricultural perspective, and a description of differences and similarities of associated schemes. Sections 3 and 4 indicate legal eligibility and different kinds of costs that PIC is related with. In Section 5 we summarize and discuss opportunities and benefits as well as challenging issues and controversies. To complement general insights, in Sections 6 and 7 we outline to what extent and how PIC is present in German national and federal state level regulation and in official offset registries. For better illustration of PIC, in Section 8 examples are presented, two with and one without an intermediary. Section 9 concludes the paper with a summary.

2. Background, Origins, and Definition of PIC

2.1. Impact Mitigation Regulation (IMR)

PIC is known in the context of German environmental compensation, based on Impact Mitigation Regulation (IMR) of the Federal Nature Conservation Act [65]. IMR was introduced to federal nature conservation policy in 1976 and it aims at no-net-loss of biotic and abiotic resources by means of environmental compensation measures for impacts on natural resources. Thus, purposeful land conversion reducing ecological value entails land conversion enhancing the ecological value in spatial, functional, and temporal correlation. According to the polluter-pays-principle, the investor responsible for the impact is liable for compensation. There is a wide range of applicability and related large amounts of resources deployed make IMR a focal tool of German nature conservation legislation [66–69].

2.2. Definition

PIC describes a compensation measure integrated into agricultural or forestry production. It yields environmental credits through altered land use practices that target defined functions and/or species, following the principle of "protection by land use".

This paper focuses on open landscapes where PIC is a defined nature conservation-oriented agricultural land use by a farmer, yielding agricultural products as well as environmental credits beyond legal standards (for discussion of PIC in forests see References [70,71]). It is financed by an investor who in return receives the environmental credits to fulfil an offsetting obligation resulting from IMR (cf. Reference [72]).

Essentially, PIC defines a mechanism where farmers take on an active part and implement a management regime that suits their farm, entailing feasibility with regards to business orientation, machinery, marketing, and staff. Maintaining eligibility for public farm subsidies (European Union single area payment scheme, see Reference [73]), farmers voluntarily enter contractual relations either directly with an investor, an administrative body, or a third party as an intermediary (see Figure 1 and Section 8 below) [34,72].

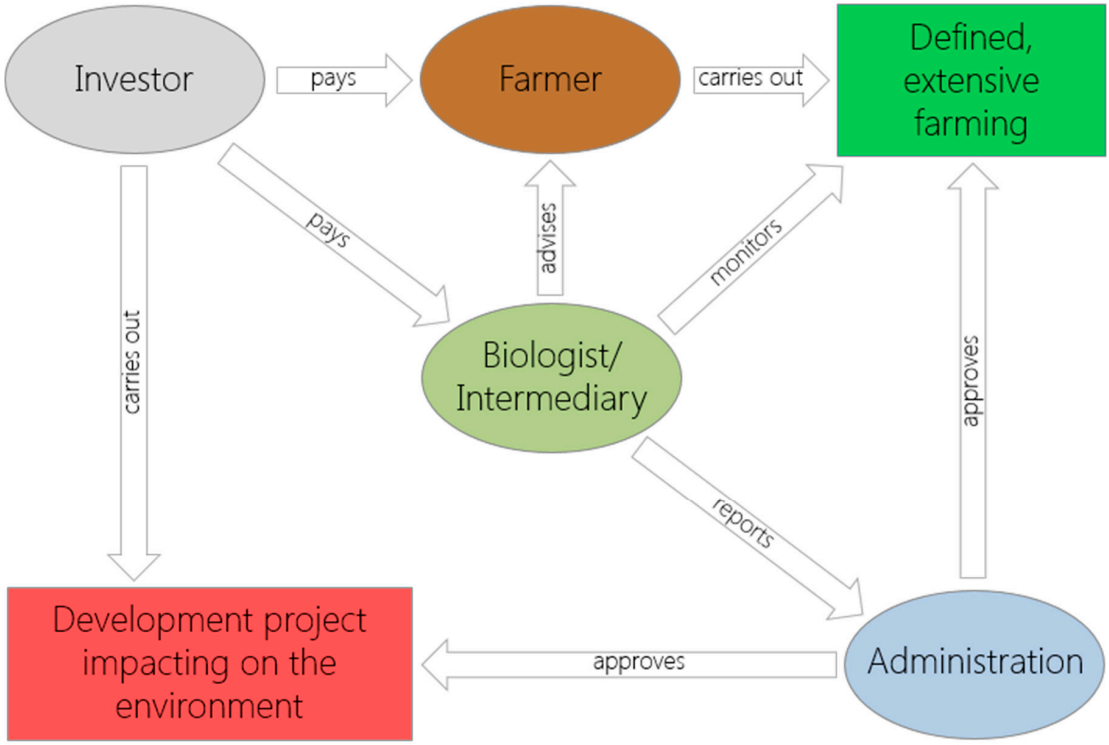

Figure 1. Model of Production-Integrated Compensation (PIC).

Figure 1 shows the interrelations of PIC as a model (from which praxis may differ):

- IMR relevant project takes place, e.g., construction project.
- The responsible investor, obliged to offset resulting environmental impacts, initiates designing of the PIC together with the environmental planner, farmer, administration, and is possibly supported by a specialized intermediary.
- Administration responsible for approving the development project, also grants permission for PIC, given the suitability for the respective impact, a thorough design, a monitoring concept, and appropriate safeguards.
- Agreement between the investor and farmer binds the farmer to implement the defined, extensive farming and the investor to remunerate the farmer.
- Agreement between the investor and intermediary/biologist binds the latter to monitor PIC implementation, to support and advise the farmer, to report to administration responsible for ensuring compensation success and binds the investor to remunerate the intermediary/biologist.

2.3. Origins and Objectives of PIC

Considering the decreasing availability of land property, the criticism of common compensation practice often ruling out arable land use, and the limitations of long-term maintenance of compensation measures [34–36], PIC emerged in Germany in 1990s, early 2000s [74–78] as an alternative concept with a different focus.

2.3.1. From Nature Conservation Perspective

From a nature conservation perspective, PIC origins lie in the objective to overcome the shortcomings of traditional compensation measures (TCM), characterized by high set-up effort including land acquisition (termed "conservation estate approach" by Reference [53]). In many cases, necessary management activities have not been carried out and established biotopes do not fulfil the ecological functions as intended [10,24,26,30]. At the same time, a large share of biodiversity in

Germany is highly dependent on extensive land management and arable wild plants and farmland birds are among the most threatened species [79–82] (for comprehensive research on endangered arable wild plants in central Germany see Reference [83]). Agriculture is, on the one hand, the driver for biodiversity loss: reasons include intensification, improved weed control, fallow land of low-productive sites, and scales of agricultural operations [84–87]. On the other hand, agriculture fostered the evolution of a particular agrobiodiversity since its beginning. Species have adapted to the specific habitat and are now dependent on it. As a result, agriculture is the key to safeguarding those species [86,88–94].

PIC can be aligned to a variety of open land species or habitats, in Germany e.g., protection of endangered arable wild plants and associations (e.g., *Sclerantho-Arnoseridetum minimae*, *Papaveretum argemones*, *Caucalido daucoidis-Scandicetum pecten-veneris*) [95], protected farmland birds (e.g., skylark *Alauda arvensis*, red kite *Milvus milvus*), or small mammals (e.g., hamster *Cricetus cricetus*, partridge *Perdix perdix*, hare *Lepus europaeus*). Also, organic farming is an option for PIC [96–98]. Accordingly, PIC habitats may be extensive fields or margins, flower strips, skylark spots, or specially managed leguminous crops (PIC can also target grassland species and habitats, but as restoration and extensification may correlate with major time-lags before showing success [33,99] and as PIC on arable land is the new and actual innovative core of PIC, this paper does not discuss grassland PIC). The particular objective is to be defined in each individual case according to the impacted environmental values. Precondition for any protection success is the suitability of land and a germane targeted management regime.

2.3.2. From Agricultural Perspective

From an agricultural perspective, the motivation regarding PIC is to reduce the loss of farmland as it is often linked to the common compensation approach. Traditionally, arable land is highly present among sites used for compensation (initial biotopes), but not among the habitats compensation is aiming for (target biotopes) [34,35,94]. A common target biotope is extensive grassland which allows for and relies on agricultural management, however, for a crop farmer, this is considered a total loss. Hence, acceptability from a farmer's perspective relates to the conversion of arable land into non-arable land, or more generally, it depends on the question whether or not the initial land use type may be maintained by the initial land user or not.

Common compensation practice increases conflicts of competing land use claims as often both land development and compensation measures result in farmland conversion [34,35,94]. To reduce adverse implications for farmers by fostering especially arable biotopes as target biotopes, and involving farmers as active partners in a cooperative way in the compensation practice is the agricultural objective of PIC [26,34,100–102].

2.4. Association to Existing Instruments and Schemes

Looking at the conservation aims and the general approach, PIC shows analogies to existing instruments and schemes, i.e., Payments for Ecosystem Services (PES), Agri-Environmental Schemes (AES), and TCM (see Table 1). Sharing the legal basis, PIC and TCM have similar legal requirements, but are different in their focal points: while TCM were in the past often oriented towards conversion of arable land and set-up activities like planting of trees etc., PIC focuses on land management for environmental gains. This conservation strategy can be found in the concepts of PES and AES, too. PES, defined as voluntary purchase of an ecosystem service by a buyer from a provision securing provider [103] (for more on PES see e.g., References [104–108]), reward and foster positive externalities and realize a beneficiary-pays-principle [109,110]. Both supplier and buyer engage in the PES transaction voluntarily [103]. PIC buyers on the other hand are obliged to finance protection measures and in the frame of a no-net-loss policy, PIC only rebalances previous negative environmental effects by a polluter-pays-principle. AES, defined as positive financial incentives for land users to increase environmental quality, realized via governmental buyers within the European Union Common

Agricultural Policy (for more on AES see e.g., References [111–118]), aims for an environmental surplus qua governmental payments, either to reduce negative externalities or to internalize and thus increase positive externalities of agricultural land use [113,119]. AESs are highly centralized, despite arguments in favor of decentralization to improve AES effectiveness [114,115,120–125], and agreements are limited to a few years. In contrast, PIC's decentralized approach employs targeting in terms of site, farmer, management regime, and payments. For compensation of long-term impacts, duration of extensive land use in the frame of PIC ranges around 20–30 years [126–128].

Table 1. Comparison of PIC and related instruments.

	PIC	TCM	AES	PES
Payments for environmental gains via land use, land user as important player	√		√	√
Voluntary buyers				√
Governmental buyers only			√	
Beneficiary pays-principle			√	√
Polluter pays-principle	√	√		
Timescale	variable, but long-term focus	variable, but long-term focus	short-term	variable

PIC = Production-integrated compensation, TCM = traditional compensation measures (land acquisition and high set-up effort), AES = Agri-Environmental Schemes, PES = Payments for Ecosystem Services.

3. Legal Eligibility

The 2009 revision of the German Federal Nature Conservation Act introduced a focus on PIC by demanding primary consideration of land use-based compensation (Section 15, subsection 3, Federal Nature Conservation Act). Nevertheless, for legal eligibility, the following requirements apply to every kind of compensation: spatial, temporal, and functional correlation of impact and compensation, improvement of status quo, and additionality. A decision on the legal compliance of each compensation measure is subject to case-by-case assessment by the authority approving the impact.

As for PIC, ubiquity and annuality of agriculture entail geographic and time-wise flexibility, allowing for spatial and temporal proximity to impacts. However, not every agricultural field is an appropriate PIC site. Suitability depends on the concrete conditions and presence of a willing and capable farmer in light of the particular conservation goal. With regards to functional correlation, PIC may best provide compensation for impacts on arable land and grassland. In Germany, these are the most common sites affected by impacts [34,35,94].

Agricultural habitats show great potential for environmental improvements from a conservation and legal point of view [82,129,130]. By initiating an extensive farming regime, PIC can efficaciously, and in arable context, quickly valorise agricultural habitats [131–134] and comply with the required improvement of the status quo.

With regards to the additionality criterion, PIC measures must not be obligatory or accounted for in any other regard (e.g., AES). Moreover, management terms have to exceed legal standards and codes of good practice relevant for general agricultural land use [130,135–137].

Adding on the content-wise requirements, every compensation measure needs safeguards. As for the site, this is possible by acquisition of the property, entries in the land register, or by lease agreements [126,130,138]. As for implementation and long-term maintenance, this is possible via a contract between the farmer and investor or the administration or an intermediary (see examples below (Section 8). The contract defines management details, payments, responses to adverse progression like dominance of non-target weeds, and other conditions relevant in this context [130,139].

4. Costs

From an economic perspective, costs are related to designing and implementing PIC, to securing the PIC property, and to monitoring the PIC implementation. Some costs arise as direct costs, some as opportunity costs, others as transaction costs; some costs occur only in the set-up period, others

continuously. For the latter, capitalization of the annual payment can limit organizational work load for the investor and help to cope with formalities (e.g., fiscal accounting) that require to finalize project related expenditures in a given period. Intermediaries can hold in trust the present value and transfer the resulting annuity to the recipient as defined [140]. Moreover, third parties offer the chance to reduce transaction costs for farmers, investors, and the administration [141]. In general, substantial transaction costs have to be assumed as PIC transactions may be characterized by high specificity, high uncertainty, and low frequency due to the novelty of the concept, high level of decentralization, and heterogeneity of actors [10,118,142–145].

Moreover, long-term implementation of PIC brings about questions of variable prices, cost increase rates, and interest rates which have to be considered [126].

4.1. Design

PIC measures need to be drafted, designed, and negotiated between farmer, investor, and the approving authority. As PIC is different from the traditional approach and is not commonly known, designing of PIC can be complex and time-consuming, hence there are transaction costs for all unexperienced parties for gathering information on the concept, on possible measures and related environmental credits, on options for safeguarding the long-term implementation and the property, and for finding farmers willing and land suitable for PIC. Then, transaction costs for bargaining between the farmer, administration, and investor accrue and may also be expected to be higher than for common compensation measures.

4.2. Implementation: Management Regime

To implement the measure and realize the extensive land management, the farmer is paid by the investor. Modifying land use from common to extensive results in reduced quantity and quality of agricultural products, i.e., opportunity costs arise. Direct costs are on the one hand influenced downwards by a decreased sowing rate, mineral fertilizer, and herbicide application. On the other hand, direct costs are influenced upwards by a necessary increase of tillage and mechanical measures for weed control, which leads to higher costs for staff, machine maintenance, fuels, and lubricants. In total, the marginal return on the PIC site is decreased. Nevertheless, compared to other conservation measures, PIC land management costs can be low ([94], detailed discussion in References [126,146]).

Moreover, related information and organizational effort can lead to considerable transaction costs for the farmer ([126,145], see also costs of AES and PES: References [147,148]). Foregone profit and costs, however, can only be the basis for the payment to the farmer. PIC is a product whose price should cover not only its costs but also a producer surplus ([34,126], see also References [149,150]) and account for factors like farming structures, conservation potential of the site, amounts of payments for AES [26] as well as long duration of PIC contracts (cf. Reference [151], for further discussion of payments to farmers for environmental gains see References [60,152,153]).

4.3. Safeguarding the Site

To ensure the availability of the PIC site, land acquisition and entries in the land register embody the highest level of security, but are at the same time the most expensive means [34,126,130]. High expenses negatively affect overall PIC cost efficiency as safeguarding the site itself does not yield environmental credits (cf. Reference [33]). Moreover, farmers' acceptance of land acquisition by non-agricultural actors in general is low [10,139]. Long-term lease agreements are in this regard the favorable option [10,139] as they are close to common practice in the agricultural sector. If covering the whole PIC implementation period, lease agreements are sufficient safeguards for site availability [138]. However, the long duration of up to 20–30 years is beyond what is common in the agricultural sector which leads to expenses for land owner satisfaction for entering into such long-term land lease agreements [139].

4.4. Monitoring

Monitoring of PIC is expensive for two reasons: (1) In contrast to compensation based on investments like planting of trees, there is not one major set-up in the beginning, but continuous implementation every year. Therefore, risk of non-implementation is high, requiring safeguards. Hence, continuous monitoring for the whole PIC implementation period is essential. (2) Monitoring effort is high since verification of whether or not the agreed management terms are respected requires on-site inspection. Depending on the PIC aim, species and general site conditions have to be evaluated which involves complex and time-consuming methods by qualified staff (cf. Reference [154]).

5. Opportunities and Challenges of PIC

PIC brings about benefits but also specific difficulties. Table 2 discusses and links opportunities with challenges. Table 3 summarizes the most important arguments for PIC from environmental, agricultural, and investors' perspective.

Table 2. Opportunities and Challenges of Production-Integrated Compensation (PIC).

Benefits and Opportunities	Challenges and Criticism
Cooperation	
Accounting for evident shortcomings of traditional compensation and cooperation with land users positively influences acceptance of PIC [33,34,139,155,156]. Focus on long-term care rather than set-up measures alters the orientation towards a reasonable and feasible consensus in consideration of all present conditions and across divergent claims, viewpoints, and actors. Cooperation implies including local knowledge and to account for local preferences by engaging with local stakeholders and the specific context ([33,34], cf. Reference [95], see also the role of local knowledge and local preferences with regards to other agri-environmental measures: [157–159]).	Cooperation across heterogeneous sectors is challenging in terms of communication and collaboration as traditional viewpoints and positions need to be transcended [126]. This leads to high transaction costs for learning about each other and for negotiating options within the given setting and constraints [160]. This effect is enhanced, when PIC is an infrequent phenomenon. The innovative approach due to its novelty, bottom-up character, and complexity is challenging and costly for all participants.
Farmer Participation	
In PIC, farmers are major players. This brings about influence for the farmers, they can express their own views and necessities regarding the compensation measure, and can ensure consideration of their farm needs and lower conflicting implications by shielding highly productive sites. By implementing PIC, farmers prevent the largely criticised loss of farm land [33,37,139,160].	Ensuring high quality nature conservation measures in line with IMR objectives apart from accounting for agricultural aspects [161] is challenging and requires safeguards.
Maintenance	
In the frame of PIC, responsibility for long-term maintenance is explicitly allocated to the farmer. Risk of neglecting maintenance is reduced [37,160].	Assurance of the farmer's compliance is crucial. Internal uncertainty referring to behavioral uncertainty as a Principal-Agent-Theory problem arises (cf. Reference [10]). Moreover, conditions of opportunism and bounded rationality (cf. Reference [10]) need to be observed. Safeguards like enforcement mechanisms as well as remedies in case of non-compliance have to be established.
Duration	
Long-term extensive land use is a substantial benefit of PIC from nature conservation point of view [81,95,162]. Especially for arable PIC, environmental time-lag is low, provided that there is a purposeful site selection and purposeful design of management regime [139].	Long-term securing of both the implementation by the farmer and the availability of the site is challenging in terms of durability and resilience of agreements. Volatility in the agricultural sector requires particular specification for trends in prices and costs in the agricultural market (cf. Reference [163]). What is more, continuous administration and monitoring of long-term PIC is costly [126,164].

Table 2. *Cont.*

Benefits and Opportunities	Challenges and Criticism
Targeting and Flexibility	
PIC employs a case by case approach. Targeting pertains to the farmer, the site, the management regime, and the payments. Heterogeneity of natural, economic, and social conditions can be respected and accounted for, which increases effectiveness [33]: Tailored management regimes can precisely promote certain threatened species [131,160,165] and include altering of constraints or rotation of sites to account for farming requirements like crop rotation [95,160]. Customizing increases chances for finding willing farmers ([139], see also [166,167]) and allows for efficient payments (cf. [112,145]).	Targeting in terms of site and conservation goals entails a high effort for selection, design, and communication (especially when aiming at e.g., endangered arable wild plants, c.f. Reference [168]). A sophisticated PIC implicates sophisticated and costly monitoring. Lack of capacities and specific know-how in administrations (cf. Reference [164]) might involve third parties for monitoring [139].The natural environment is characterized by high external uncertainty [10]. Mechanisms of coping with unforeseen progression of the site and with regards to the conservation goal have to be established.
Finances	
PIC expenditures can focus on implementation instead of property acquisition [33,126,160]. Contracting a farmer for implementation brings about a new, long-term, and calculable source of income for farmers [26,53,63,102,160,169,170].	PIC is sometimes interpreted as a subsidy for farmers and is criticized for fostering deadweight effects (e.g., Reference [171]). However, as payments to farmers are payments for certain services in return, they are not subsidies and farmers' profits are ordinary producer surpluses [119].

Table 3. Overview on benefits and opportunities of Production-Integrated Compensation (PIC).

	Benefits and Opportunities Related to PIC
For Nature Conservation	Protection of strongly endangered species (farmland flora and fauna). High functional correlation with common impacts, fostering diverse open landscapes. Increased acceptance of Impact Mitigation Regulation and less conflicts. Money spent on implementation instead of land acquisition.
For Agriculture	Farmers as partners and active and important players. Sustaining arable farmland, eligible for EU single area payment scheme. New source of long-term income. Focus on marginal land, less valuable for agriculture.
For Investors	Increased availability of compensation sites. More options for compensation. Increased acceptance of compensation measures.

6. PIC Framework Conditions in Germany

Since the first ideas of PIC, framework conditions have changed. Details have been elaborated and PIC-relevant subjects have been integrated into regulations and guidelines.

To assess the framework conditions with regards to PIC, we investigated PIC-relevant documents in Germany. Included were IMR-related documents published by legislative or administrative bodies of the agricultural, environmental, or road construction sector (Ministerien, Straßenbauämter, Landesumweltämter, Landesanstalten, Landesbetriebe). Considering concurrent legislation allowing for state-specific deviations in the field of IMR, the review focused both on the federal and state level.

Results show that, as of 2018, framework conditions for PIC are very diverse and include laws, regulations and PIC-specific guidelines (see Table 4).

Table 4. Assessment of Production-Integrated Compensation (PIC) framework conditions in Germany.

SubjectState	B	BB	BW	BY	HB	HE	HH	MV	NI	NW	RP	SH	SL	SN	ST	TH	DE
PIC concept present																	
Descriptions of PIC land management																	
Environmental yields by PIC																	
Reference to impacts for PIC																	
Reference to legal standards, subsidies, or funding regarding PIC																	
Specification of PIC duration																	
Other PIC relevant specifications																	
Overall assessment																	

Explanations: B: Berlin, BB: Brandenburg, BW: Baden-Wuerttemberg, BY: Bavaria, HB: Bremen, HE: Hesse, HH: Hamburg, MV: Mecklenburg-Western Pomerania, NI: Lower Saxony, NW: North Rhine-Westphalia, RP: Rhineland-Palatinate, SH: Schleswig-Holstein, SL: Saarland, SN: Saxony, ST: Saxony-Anhalt, TH: Thuringia, DE: Germany. Green/yellow/orange indicate high/medium/low level of concreteness, comprehensiveness, and legal binding force of regulation on the subject; red indicates no regulation on the subject.

The Federal Nature Conservation Act mentions land use management as a priority option for compensation, but details are only provided by a directive for compensation of federal highway projects [156,172]. A federal compensation ordinance drafted in 2013 [173] includes concrete and comprehensive standards for PIC. It, however, has not entered into the force.

In most federal states, PIC regulations are partial, are not legally binding, refer only to certain sectors (especially for highway projects), or are abstract. Often, not laws or compensation ordinances, but publications by different kinds of administrative bodies constitute a detailed framework. Highest levels of concreteness, comprehensiveness, and legal force of the PIC framework are available in Berlin, Brandenburg, Bavaria, Hesse, Lower Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saxony, and Thuringia. The City States of Bremen and Hamburg as well as Saarland are found to have the least elaborated framework. Noteworthy are PIC-specific decrees and guidelines available for Brandenburg [174], Bavaria [175], North Rhine-Westphalia [176], and Thuringia [177].

IMR application specifications serve as orientation, which on the one hand may promote PIC realization by reducing knowledge gaps, uncertainty, and definition efforts, but on the other hand may hamper PIC realization by limiting overall flexibility, targeting options, and practical adaptions.

7. PIC in Offset Registries in Germany

Compensation measures are to be documented in offset registries [65]. To gain an overview on the implemented compensation measures in Germany and to assess PIC representation, we investigated the offset registries of the 16 German states and the national level in early 2018, considering levels NUTS-1 and NUTS-2.

Results show that only in few states, offset registries are in place, are accessible, and allow for identification of PIC. In six states, arable PIC are documented, referring to approved measures like extensive farming and protection of farmland species (see Table 5). The number of PIC measures and the area covered is only very small. Valid quantification of the relation of PIC to other compensation measures, however, fails due to incomplete data sets. The obvious lack of detailed data inhibits comprehensive assessment of data (see also [16] with regards to transparency of no-net-loss policies in Europe).

Table 5. Production-Integrated Compensation (PIC) in offset registries.

Results of Offset Registry Analysis	State
No information	SL
State offset registry incomplete/not accessible/not in place	RP, ST, DE
Only small scale offset registries (NUTS-3) in place	BB, BW, NW, NI
No arable PIC * identifiable in registry	B, HB, SH
Arable PIC * documented: • extensive arable land use • arable field margins • flower strips • conservation fields with adapted land use • integration of fallow periods in farming • adapted farming for protection of defined farmland species (European Hamster, Skylark, Red Kite, arable wild plants)	BY, HE, HH, MV, SN, TH

* Arable PIC refers to measures implemented by farmers in the frame of arable land use. Explanations: B: Berlin, BB: Brandenburg, BW: Baden-Wuerttemberg, BY: Bavaria, HB: Bremen, HE: Hesse, HH: Hamburg, MV: Mecklenburg-Western Pomerania, NI: Lower Saxony, NW: North Rhine-Westphalia, RP: Rhineland-Palatinate, SH: Schleswig-Holstein, SL: Saarland, SN: Saxony, ST: Saxony-Anhalt, TH: Thuringia, DE: Germany.

8. PIC Examples

Apart from the poor representation in official offset registries, there are diverse examples of PIC available throughout Germany (Tables 6 and 7). Variety in PIC practices reflects the case by case approach and the high influence of local and regional actors on the design.

Table 6. Production-Integrated Compensation (PIC) examples without intermediary.

	Example from Central-Eastern District of Arnsberg, Federal State of North Rhine-Westphalia *	**Example from Thuringian Basin, Federal State of Thuringia ***
Impacting Project	Mining	Railway construction, landfill site
Investor	Private company of the mineral resources industry	German railway company
Management terms	Promotion of arable wild plants via extensive field strips; management regime based on regional regulation on contractual nature conservation plus: • requirement of growing grain • root crops possible twice in 5 years, but not creditable in these years • rotation possible, accounting for farming as well as ecological needs	Promotion of arable wild plants via extensive management of fields and field strips: • no application of mineral/organic fertilizer • no application of herbicides • 60% winter grain in crop rotation • 50% reduction of sowing rate • stubble clearing only after Oct. 15th • reduction of ploughing depth In the case of problematic abundance of non-target plants, exceptions are possible in coordination with nature conservation administration
Area	Large-scale, split in several fields	5 hectares, split in several fields
Duration	25 years	10 years
Payments to farmer	Investor pays several farmers, amount not disclosed	500 € per year per hectare, after a positive monitoring result; amount based on payments for agri-environmental measures
Safeguards	Management agreements between investors and farmers define management terms; contract between investor and district administration ensuring acknowledgment of extensive field strips as compensation	Management agreement between nature conservation administration and farmer Defines management terms, duration, and remuneration
Monitoring	Annually, carried out by a botanist, assigned by the nature conservation administration, paid by the investor; field strips are only credited in case of positive monitoring results	Annually, carried out by the nature conservation administration, including a site visit together with the farmer
Résumé	Farmers' chances to co-shape the management regime positively influenced acceptance; Environmental credits result in deposits of the company's eco-account; District administration ensures that fields will not be legally protected to still allow for future mining	Positive, trust-based, direct cooperation between farmer and administration led to voluntary increase of the PIC area as this brought about improved field demarcation for machine management; moreover, it led to a confession of the farmer when he once accidently applied herbicides

* source: [178], published in [127].

Table 7. Production-Integrated Compensation (PIC) example with intermediary.

	Example from Rhineland, Federal State of North Rhine-Westphalia *
Intermediary description and background	The Rhineland region is characterized by productive fertile plains, high agricultural yields, and high demand for property. The main finding of the project on options to realize nature protection aims in such conditions was that efficient and environmentally effective activities rely on a cooperative approach, resulting in the founding of the Rhineland cultural landscape trust ("Stiftung Rheinische Kulturlandschaft"); constituted by agricultural players (regional agricultural association, chamber of agriculture) in 2003, the trust aims at preservation of the (agri)cultural landscape and acts as an intermediary for PIC
Intermediary Services	Comprehensive facilitation of PIC: identifying suitable sites, aligning management terms and safeguards with farmers and administration, implementing long-term monitoring and reporting, providing advice in all PIC phases; services are available to all investors, based on implementation contracts specifying the scope, PIC measure, compensation credits, duration, and capitalised costs including accounting for risks
Management terms	Promotion of farmland birds, arable wild plants, abiotic resources, and landscape aesthetics, focusing on less favorable, marginal farmland or field strips: • limited application of mineral/organic fertilizer and no herbicides • defined crop rotation incl. nurse crops • reduced sowing density • late stubble clearing • no ploughing • rotation possible within a defined scope, environmental suitability given Management terms are defined in close cooperation with parties to ensure appropriateness for the farm and conservation goal; when causing problems, terms may be changed in coordination with the nature conservation administration
Duration	5 years minimum, with prolongation option, accounting for low farmer acceptance of longer periods
Payments to farmers	Annually, payments depend on positive monitoring results (with regards to conservation goal and management terms compliance); amount is based on production costs and opportunity costs
Safeguards	Sites • Land acquisition by the intermediary, entries in land register, or long-term land lease agreements • No site safeguards for rotating measures → increased site availability because absence of sale and negative side effects of land register entries like depreciation increase willingness of land owners Measures • Management agreements between the intermediary and farmer specify management terms, safeguarding mechanisms, duration, and remuneration; they include action-oriented and result-oriented conditions as well as support and mentoring to the farmer Finances • The intermediary receives and holds in-trust capitalized costs for each PIC and pays out annually, which allows to reallocate payments in case of compliance problems or a switch of farmers By pooling compensation measures, sites, and money, the intermediary can arrange workarounds or substitutions in case of problems and, by this, ensure long-term PIC
Monitoring	Annual site visit by the intermediary, reporting to administration, advice to farmers, if needed
Résumé	The intermediary as a long-term player in the field of agriculture and nature conservation entails a positive and reliable relationship with farmers as well as administrations, resulting in successful PIC.

* Source: [34,140,178].

9. Conclusions

In environmental offset policies, production-integrated compensation (PIC) is a way to achieve environmental gains by adapted farming. The wide spread of farmland in need for revaluation of the agro-ecosystem qualifies PIC to comply with offsetting criteria of spatial and temporal correlation with impacts. With regards to functional correlation, PIC is suitable to rebalance affected biotic and abiotic assets in the common cases of impacts on farmland. For legal eligibility, PIC measures need to be implemented without other obligations and to exceed legal farming standards like codes of good practice. Success criteria are cooperation with farmers, jointly elaborated farming terms targeting defined abiotic functions and species, purposeful selection of the site, and monitored long-term management by farmers. Furthermore, intermediaries may provide valuable knowledge and support to public authorities, investors, and farmers for the design and implementation phase.

By protection of endangered open land species and maintaining farming, PIC addresses nature conservation as well as agricultural objectives. The communication efforts are challenging compared to commonly applied compensation practices, affecting all actors. Framework conditions and standards for PIC realization are just evolving, involving uncertainty, but at the same time, flexibility for customized implementation.

In light of the high global demand for compensation measures as well as for farmland, the integration and cooperation approach of PIC may be an option also in other settings.

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