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Environmental Evidence

SYSTEMATIC REVIEW

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What are the environmental impacts of property rights regimes in forests, fisheries and rangelands?

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Abstract

Background: Property rights to natural resources comprise a major policy instrument in efforts to advance sustainable resource use and conservation. Debate over the relative effectiveness of different property rights regimes in reaching these goals remains controversial. A large, diverse, and rapidly growing body of literature investigates the links between property rights regimes and environmental outcomes, but has not synthesized theoretical and policy insights within specific resource systems and especially across resource systems.

Methods: We conducted a systematic review following CEE Guidelines in which we collected empirical evidence from the past two decades on the environmental impacts of property rights regimes in fisheries, forests and rangelands in developing countries. We used a bundle of rights approach to assess the impacts of state, private, and community property regimes, as well as mixed regimes and open access conditions. Outcomes were classified as positive, negative, neutral or undetermined. We also collected information on contextual and other factors thought to influence effect of property rights regimes on environmental outcomes. The search covered 90 online databases and three languages, resulting in a total of 34,984 screened titles.

Results: This review identified 103 articles consisting of 374 property regime studies: 55% of the studies related to forestry, 31% to fisheries, and 14% to rangelands. The majority of the studies comprised case–control studies but presented limited information on the baseline condition of the resource system. Only 26 studies used before-after-control-impact (BACI) design. We found that property regime comparisons differed across resource domains with, for example, the majority of fisheries studies using comparison to an open access situation while forest and rangeland studies were more mixed in regime comparisons. After critical appraisal of included studies, only 80 studies were accepted for the narrative synthesis. The key contextual factors largely associated with reported positive environmental outcomes across the three resource systems included monitoring and enforcement systems, resource use pressure, and the presence or absence of clear, stable and legitimate rights (i.e. 'positive regime characteristics').

Conclusions: A key overall finding was that the evidence base was insufficiently robust to draw consistent conclusions about the environmental impacts of different property rights regimes within or across resource systems. The majority of studies reported that any regime is likely to perform better than an open access regime, whereas the performance of state, community, private and mixed regimes was much more ambiguous. Future research on property rights regimes would benefit from more rigorous study designs and more cohesive multidisciplinary research methods. In particular, studies emphasizing a natural science approach could better describe property rights regime characteristics and contextual factors while contributions by teams with a stronger social science emphasis should take care to provide more rigorous empirical data on environmental outcomes.

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Background

Property rights regimes consist of systems of rules that govern access to and control over natural resources. These rules specify permissible and forbidden actions, responsibilities and obligations among people and in relation to natural resources [1, 2]. Property rights regimes are an essential part of natural resource governance as they affect how the costs and benefits of natural resources are distributed [3]. They influence the resource management incentives of different actors and, ultimately, shape resource conditions as well as livelihood outcomes.

Debate over the effects of different property rights regimes on natural resource systems has long been controversial. The dominant paradigm held that government or private property was required for conservation and sustainable resource use, as typified in Hardin's [4] thesis that common pool resources will inevitably suffer from overexploitation and degradation. However, a large body of scholarship has since demonstrated the limits of Hardin's argument, showing that expanding the breadth of property rights held by local-level actors in common property regimes can lead to efficient and effective outcomes for resource sustainability [1, 5, 6]. The devolution of property rights to community and local-level actors has since been used as an instrument for achieving goals as disparate as poverty alleviation [7], gender equity [8], resource conservation [9], and climate change mitigation [10]. Of course, states have also retained or claimed new property rights and simultaneously allocated them to private sector actors in the name of these same goals [11].

Understanding environmental outcomes of property regimes is important because improving environmental conditions (e.g. reducing deforestation) has been the objective of a variety of tenure reforms, which have often been costly and have taken long periods of time to yield results. Evidence of the success of these programs is limited, with some studies finding success in tenure devolution programs [12] and others finding they may not have had their desired effects [13]. Property rights schemes inappropriate to particular resources or social-ecological context may cause tenure insecurity and other undesired outcomes as assessed through analysis of local conflict, policy enforcement, displacement, or incidence of squatting [14].

Research investigating the causal relationship between property rights regimes and environmental outcomes has identified a diversity of contextual factors that affect the success and failure of common property regimes [15], with particular emphasis on the importance of institutional factors [16]. The empirical basis for much of this research relates to community forestry in specific country or regional contexts, although the question of property regime performance is also pertinent in other natural resource systems and tenure regimes. Broadening the scope to examine environmental impacts of different regimes across resource systems and regions thus allows for a comprehensive evaluation of individual property regime types in comparison to others, with particular attention paid to contextual factors that may have further contributed to or detracted from these outcomes.

For this review, we chose to examine forests, fisheries and rangelands due to the importance of the ecosystem services they provide as well as their broad geographical coverage. Millions of people also directly or indirectly depend on these resources for their livelihoods. This systematic review synthesizes the empirical evidence on the environmental impacts of different property rights regimes in these resource systems in developing countries. Our review also considered variables on social, economic, and political context to shed light on how contextual elements are understood to influence the environmental outcomes of property rights regimes.

Objectives of the review

The primary research question was:

- What are the environmental impacts of different property regimes in forests, fisheries, and rangelands in developing countries?

We also posed two secondary questions:

- Which property regimes are associated with positive, negative or neutral environmental outcomes?
- How do those environmental outcomes compare within and across resource systems and world regions?

The review adopted a PICO structure (population-intervention-comparator-outcomes) to answer these questions. The PICO structure is summarized below and is presented in greater detail in the protocol for this systematic review [17].

Population

The populations of interest are any of the three resource systems covered by this review: forests, fisheries and

rangelands. Definitions for each of these resource systems can be found in Additional file 1.

Intervention

The intervention refers to an existing property regime or introduction or change in the particular property rights regime under study. Property regime, is understood as a system of rules that govern access to and control over resources [18] encompassing state, private, or community regimes. Additionally, a combination of two or more of these regimes (mixed regimes) and "open access" situations where access and withdrawal rights were open to anyone are also considered in the review. We focused on property rights regime interventions in developing countries because majority of tenure regime transitions over the past decade have taken place in developing countries [19].

In determining regime types, we used a bundle of rights approach as proposed by Schlager and Ostrom [20] to consider whether community, state, or private actors hold access, withdrawal, management, exclusion, and alienation rights (Table 1). We have added the right to income to this list in consideration of its potential significance as part of the incentives for sustainable resource management [21, 22]. Although we base our analysis on the bundle of rights expressly mentioned in the studies, we made three additional assumptions on the nature of property regimes. First, in accordance with the hierarchical and cumulative nature of Schlager and Ostrom's framework, if the actors held management rights or engaged in management activities, we assumed that the same actor also possessed access and withdrawal rights. Second, for state protected areas (e.g. national parks), we assumed the state was the holder of de jure rights from access to alienation. Third, for private regimes (e.g. private farms), we assumed that the private actors held de jure rights from access to exclusion.

Table 1 Bundle of different property rights

Property right	Definition
Access	The right to enter a defined physical property
Withdrawal	The right to enter a defined physical area and obtain resource units or products of a resource system (e.g., cutting firewood or timber, harvesting mushrooms, diverting water)
Management	The right to regulate internal use patterns and transform the resource by making improvements (e.g., planting seedlings and thinning trees)
Exclusion	The right to determine who will have right of withdrawal and how that right may be transferred
Alienation	The right to sell or lease withdrawal, management, and exclusion rights
Income	The right to earn income from a resource even without using it directly and is derived from permitting others to use the resource

Comparator

This review compared environmental outcomes based on analysis of studies using the following three study designs:

1. Studies that compare environmental outcomes before and after intervention (temporal comparison).
2. Studies that compare environmental outcomes by comparing intervention sites to control sites without the intervention (spatial comparison).
3. Studies that combine temporal change and spatial comparison, so called BACI—before-after-control-impact—design.

Outcomes

The outcome of interest in this analysis consists of qualitative and quantitative information on environmental measures (e.g. fish biomass, forest cover, species abundance), as well as changes in environmental measures (e.g. deforestation rate, change in coral cover).

Methods

Searches

The search strategy followed that published in the Protocol [17], with variances stated in Additional file 2. References from previous systematic reviews (e.g. [23, 24]) and other literature reviews identified during the search (e.g. [14, 25, 26] were hand-searched to identify further relevant articles.

In addition to English, the search for literature was also conducted in French and Spanish. A native French speaker (Louis Durey) and a native Spanish speaker (SN) conducted the searches in selected academic databases, general web databases as well as in specialist websites. Additional file 3 presents the detailed searches in different databases. An initial scoping search was also conducted in Finnish and Indonesian, as these were other languages known by the review team. The search was conducted between March and June 2014, with an updated search for 2014 carried out for Web of Knowledge in July 2014 and for CAB in August 2014. We searched the databases in July and August so note that 2014 is an incomplete year because publication in bibliographic database lags behind that in the primary journals and most journals were only half-way through their annual publication cycle.

Article screening and study inclusion criteria

In the protocol we had stated that a 3-stage screening process would be used; however, a pilot title screening revealed that we could reject only an insignificant number of articles based on a review of titles alone. This was likely due to our relatively broad inclusion criteria as well

as generally broad article titles. Therefore, we considered the most efficient way of screening would be achieved by combining title and abstract screening, and so screened based on titles and abstracts followed by full texts. Articles were included if they met the following criteria.

Relevant subject populations

The relevant subjects in this review were forests, fisheries and rangelands. Plantation forests, agroforestry and aquaculture were excluded as not meeting our definition of (natural) forests and fisheries.

Relevant interventions

We included articles that presented studies of existing property regimes or an introduction or change in the particular property rights regime under study. Articles reviewing environmental outcomes without a clear reference to a specific property regime were not included.

Relevant comparators

Only articles presenting experimental or quasi-experimental studies using before-after, BACI study or case–control comparators were included.

Relevant outcomes

The relevant outcomes were quantitatively and/or qualitatively measured changes or differences in environmental outcomes. Articles that only presented studies with indirect environmental outcomes (such as amount of fuelwood consumption) were excluded.

Relevant study locations

This review focused on developing countries in Africa, Asia and the Pacific, and Latin America and the Caribbean (see Additional file 4 for a complete list of countries). Developing countries were those defined as being either low, lower-middle or upper-middle income according to the World Bank [27].

Relevant timeframe

Only articles published between 1990 and 2014 were considered for the review. The year 1990 was chosen as research on the commons increased rapidly during the 1990s in the wake of Ostrom's landmark work that year [1].

Two additional inclusion criteria were applied at full-text screening phase. First, the articles had to present a property regime with site-specific environmental and contextual data, rather than presenting outcomes on a regional or national scale. Second, at least one right in bundle of rights needed to be clearly presented in the study, as it would serve as the basis for regime descriptions. All the articles that did not meet the additional criteria were noted and presented in Additional file 5. All the articles that met the inclusion criteria are listed in Additional file 6. Although existing systematic reviews have excluded articles that lack a significant (33–50%) portion of the data [23], we decided not to exclude such articles in order to retain relevant evidence.

Seven reviewers were involved in the title and abstract screening and four reviewers conducted full text screening. To check for consistency of reviewers, kappa statistics were calculated for title and abstract screening, full text screening and critical appraisal. If the kappa statistic fell below 0.6, reviewers met and discussed screening disagreements. Only when a satisfactory kappa statistic was reached did reviewers continue individually. During the first round of screening, 1836 titles and abstracts were screened by two or more reviewers. As our inclusion criteria allowed some room for interpretation, the initial kappa was very low (0.3). Further discussions between the reviewers raised the kappa to moderate- to high-levels of consistency (0.5–0.8). At full text screening, four reviewers in pairs of two screened 199 articles and a high level of agreement was reached between reviewers (kappa statistics of 0.7–0.9).

Potential effect modifiers and reasons for heterogeneity

We collected a set of additional regime characteristics and contextual factors in order to explain the nature and variation of the outcomes of the property rights regimes. Based on the recommendation of previous reviews [23], we concentrated on a number of confounding variables and contextual factors (Table 2). Along with expertise within the review team, we also drew on input from an advisory group consisting of researchers with experience on property rights issues across forests, fisheries, and rangelands to identify potential effect modifiers (contextual factors). Furthermore, we created a set of initial hypotheses that linked the contextual factors with positive or negative outcomes, to ensure we were examining meaningful contextual factors. The number of potentially relevant hypotheses and variables was finally winnowed down to a manageable set that addresses especially salient issues in the property rights literature.

Critical appraisal of included studies

Studies that passed full text screening were critically appraised according to the following assessment criteria, with results recorded in a separate Excel spreadsheet (Additional file 7). As the individual studies within a single article shared methodological characteristics, the results were recorded at article level only. Explanations for each decision were recorded in order to keep the process transparent and replicable.

Table 2 List of potential effect modifiers and reasons for heterogeneity

Contextual factor	Hypothesis	Direction of hypothesized environmental impacts	Information collected from the articles
Environmental context			
Location	No specific hypotheses. High variation confounds results	None	Subnational Country World region as classified by UN Stats
Ecosystem type			A specific description of the ecosystem
Spatial extent of resource area	Larger areas are associated with better environmental outcomes (especially for community regimes)	+	Size of the area
Elevation	Resources at higher altitudes are often less accessible and thus likely to have better environmental outcomes	+	Elevation stated in the article
Accessibility	Proximity to roads and cities facilitates resource extraction as well as increases resource use pressure	−	Proximity to roads and cities
Quality of baseline resource condition	Resources with better baseline conditions are likely to have better environmental outcomes	+	Baseline resource conditions
Existence of external environmental management interventions	Presence of previous environmental projects such as conservation programs may lead to greater awareness about environmental issues by resource managers and local populations, which in turn may lead to better environmental outcomes	+	Presence of previous environmental initiatives, such as conservation projects
Additional regime characteristics			
Clarity of rights	Clearly defined property rights allows for better management which leads to better environmental outcomes	+	Defined as "clear", if the study had information on both de jure and de facto rights and no disagreements or conflicts between users were cited
		−	Defined as "unclear", if the study mentioned several right holders and presence of disagreements or conflicts over rights
Stability of rights	Greater stability of rights (e.g. security of tenure) encourages greater investment in management which leads to better environmental outcomes	+	Defined as "stable", if the study had no information on the likelihood of revocation of rights or limitation to the duration of rights. Rights limited in scope (e.g. rights only to NTFP products) were not considered as part of the stability question
		−	Defined as "unstable", if the study mentioned conflicts and had information on the likelihood of revocation of rights or limitation to the duration of rights
Level of enforcement	Presence of high levels of enforcement will lead to better environmental outcomes	+	Information on enforcement (e.g. patrolling and monitoring)
Legitimacy of decision-making authority over rights	High legitimacy of decision-making authorities will lead to higher compliance with resource management rules which will affect environmental outcomes	+	Information regarding internal decision making processes, and to what extent was the decision making inclusive (not excluding certain groups)
Gender equity of property rights	Gender equity in the distribution of property rights provides greater incentives for women to participate in decision-making over resource management and use. When women are involved in decision-making, levels of compliance among the community should increase, reducing the occurrence of disruptive conflicts and thus may lead to better environmental outcomes	+	Information on gender equity in the distribution of property rights
Presence of external support	Greater external support for property rights regime (with objective of environmental benefits) will lead to better environmental outcomes	+	Information regarding support by external actors such as NGOs, donors, or companies for the property regime was noted

Table 2 continued

Contextual factor	Hypothesis	Direction of hypothesized environmental impacts	Information collected from the articles
Protection status	If area is formally protected by law, designation, or customary practice, better environmental outcomes are expected	+	Classified by the following designations: IUCN protection category and other kinds of formal protection; informal or private protection (without state recognition); not a protected area
Socio-economic context			
Population	High population density may result in higher surrounding resource use, leading to resource degradation	−	Population density and change in population in the study/resource area
Market demand on resource	High local and external demand results in greater resource use, leading to resource degradation	−	Local and external market demand
Economic inequality	High economic inequality may result in conflict and undermine incentives for sustainable resource use, and may result in worse environmental outcomes	−	Measures of economic inequality as stated in the study and as reported by Gini index
Presence of environmental education initiatives	Education may lead to greater environmental awareness and thus to better environmental outcomes	+	Information on environmental education initiatives,such as a conservation programme with educational component
Presence of public infrastructure	Presence of public infrastructure may facilitate greater access, demand and use of natural resources and thus lead to worse environmental outcomes	−	Information on presence of infrastructure e.g. roads, ports, power supply
Political context			
World Bank income level	No specific hypotheses. High variation confounds results. Income-level used simply to classify countries		Classified as low, middle or upper middle income countries
History and presence of decentralization	Successful decentralization of resource management may result in greater local accountability, resulting in better environmental outcomes	+ (if decentralization is successful)	History and presence of decentralization
Nature of the political regime	The presence of democratic political processes and freedoms may allow for greater participation in decision-making, resulting in improved environmental policy formulation and implementation which leads to better environmental goals	+	Nature of political regime
Corruption	The presence and level of corruption may undermine incentives for sustainable resource use and lead to worse environmental outcomes	−	Presence of corruption in the study and as reported by the Transparency International corruption index

Questions and coding system used to guide the critical appraisal

1. Clarity and replicability of methods: Are the research methods clearly presented so that the research could be repeated? (clear and repeatable = 1, not clear and repeatable = 0).
   While undertaking critical appraisal, we found it particularly difficult to evaluate the clarity and replicability of methods presented in the included studies, so six additional sub-criteria were created to better define this criterion. If studies met at least five of the following sub-criteria, they were then given an overall score of one for having clear and replicable methods. Studies that met four or fewer sub-criteria were given marks of zero.
   1.1. Is the research question clearly stated? (clear = 1, not clear = 0).
   1.2. Is PICO defined? (yes = 1, no = 0).
   1.3. Is the selection process of PICO elements clearly explained? (yes = 1, no = 0).
   1.4. Is bias discussed? (yes = 1, no = 0).
   1.5. Is data source mentioned? (yes = 1, no = 0).
   Sub-question 5 was important for studies where the authors used secondary data, such as satellite data or aerial images, in order to identify the primary data source.
   1.6. Is study period stated? (yes = 1, no = 0).

2. Appropriateness of methods: Are the research methods appropriate for addressing the research

question(s)? (appropriate = 1, not appropriate = 0).
3. Sample size: Is the study sample size explained and well justified? (yes = 1, no = 0).
4. Confounding factors: Did the study account for and seek to minimize the effects of potential confounding factors in its design and analysis? (yes = 1, no = 0).

We chose to analyze bias in two different questions (1.4 and 4), as the discussion of bias documented in subquestion 1.4 does not necessarily mean that researchers actively sought to minimize its effects in their studies.

To test for the consistency of reviewer appraisals, a random sample of 20 articles was used to test the coding protocol and inter-coder reliability. Kappa values were calculated for each of the 5 quality questions until medium to high rates of agreement were reached (0.6–1). As noted earlier, the critical appraisal question on the clarity of methods required further explanation through the addition of sub-questions before sufficient reviewer consensus was reached.

Data extraction strategy

Data on individual property regime interventions and their environmental outcomes were collected in a data extraction matrix using an Excel spreadsheet (see Additional file 8).

In order to record the regime-specific contextual factors for each regime, we extracted each property regime as an individual study. We thus defined a study as a unique property regime for which specific environmental and contextual information was presented in an article. For the purpose of the analysis, multiple regime comparisons (e.g. state vs. private vs. community) were disaggregated into binary comparisons (e.g. state vs. private, private vs. community, state vs. community).

Table 3 features the main variables extracted on research methods, property regimes and environmental outcomes. We followed the data extraction plan as outlined in the review protocol, although we decided to collect information on study disciplines and data collection methods instead of data analysis methods in order to assess the extent of multidisciplinary research.

Regarding the assessment of environmental outcomes, we recorded the environmental indicators used by the as well the measured results and author's conclusions on environmental outcomes. Based on measured outcomes and author conclusions, we also made our own assessment of the environmental outcome(s). This reviewer assessment was the basis for the environmental outcome variable used for the analysis. The outcomes were categorized as positive, negative or neutral (similar), meaning that no significant changes were observed.

If studies featured several environmental indicators, the environmental outcomes were based on the reported statistical significance from the key indicators identified by the article authors. If key indicators were not specified, we coded environmental outcomes based on overall tendency among included indicators. If the author didn't perform or report statistical analyses, the environmental outcome was based on the characterization of the majority of indicators used: if majority of the key environmental indicators indicated negative change, the outcome was classed as negative. If this was not possible, i.e. insufficient clarity on the key indicators, the outcome was classed as undetermined.

To test for the consistency of data extraction across reviewers, four articles were coded together by four reviewers before individual data extraction began. The review team also actively discussed problematic and ambiguous studies to ensure common understanding in coding.

We also recorded additional contextual information derived from external sources on national corruption and economic inequality. We used indices for national corruption from Transparency International [28] and the Gini index as a measure of economic inequality [29]. As these indices are updated frequently, we extracted values from the year when studies were conducted. If articles didn't provide study years, we used the publication year as a reference. The methodology for the corruption index by Transparency International has changed over the years, and the scores from different years are not comparable. The Gini index however has used consistent methodology and thus the scores can be compared over time.

Data synthesis and presentation

As anticipated in the protocol [17], a significant part of the analysis we present here is descriptive and qualitative due to the nature of the information available. The diversity of the environmental indicators and analytical methods used in the included studies presented significant challenges for the meta-analysis. For example, we identified at least 59 different measurements for fisheries (e.g. fish biomass, coral cover, individual species density), 80 different measurements in forestry (e.g. deforestation rate, basal area and species richness) and 27 different measurements in rangelands (e.g. total plant cover, plant height, people's perception of change in rangeland conditions). In addition, the environmental results were expressed using different units and values, and therefore effect sizes could not be calculated.

Due to the great variety of reported environmental measurements, we have summarized findings based on reviewer assessments of environmental outcomes, which have been further weighted by study critical appraisal

Table 3 Main variables extracted on research methods, environmental context, regime description and environmental outcomes

Research methods	
Study discipline	Social sciences, natural sciences or mixed
Study years	Year(s) when environmental data was collected
Environmental context	
Resource system	Forests, fisheries or rangelands
Location	Country and region as defined by UN statistics
Regime description	
Distribution of bundle of rights (de jure)	Rights were noted as belonging to state, community and/or private. If a particular right was not described, it was noted as undefined
	Rights were defined as de jure when this was explicitly mentioned by authors. For example for community regimes, this required that the article mentioned specific rules and laws, formal state recognition for devolution of rights or decentralization
Distribution of bundle of rights (de facto)	Rights were noted as state, community, private, open access or undefined
	Rights were defined as de facto if there was no explicit reference to formal rules or regulations. For example, if the article referred to communal lands or discussed community management, the rights were defined as de facto
Nature of the regime de jure and de facto (based on bundle distribution)	State regime: state holds the rights
	Private regime: Individual or "legal individual" holds rights
	Community regime: group members hold rights (e.g. community)
	Mixed regime: Regime where withdrawal, management or exclusion rights are shared. We did not use alienation right as an important determinant because very few articles had information on alienation
	Open access: everyone can access or withdraw resources. Open access was only used as de facto-regime
Objective of the regime	Stated objective of the regime
Regime intervention year	Year(s) when intervention took place
Environmental outcomes	
Environmental measures and indicators used in the study	Specific measurements and indicators used to describe environmental outcomes
Environmental outcomes as stated by authors	Reported study results on biological outcomes
	Study conclusions on biological outcomes
Review team assessment of the environmental outcomes	For before-after comparison: negative or positive compared to baseline measurement. If there was no change observed compared to before, change was neutral. If the main direction of the results could not be determined (e.g. both significant positive and negative changes occurred), the outcome was noted as undetermined
	For case–control comparison: better, worse or similar (neutral) compared to comparison regime. If the direction of the results could not be determined (e.g. both significant positive and negative changes occurred), the outcomes were noted as undetermined
	BACI study: a combination of the previous two

scores. For the contextual analysis, we used the factors that were most frequently used in the evidence base, with certain alterations discussed in detail below.

Results

Review descriptive statistics

Figure 1 shows the step-by-step results from the search and screening process. The breadth of the review population meant that our initial search retrieved a total of 58,883 hits. Due to the incompatibility of certain sources and databases with Endnote's import function, we conducted some of the screening directly on the websites where articles were found. However, we were able to remove 23,298 (40%) duplicates from the initial search results with Endnote and 601 duplicates manually, resulting in 34,984 titles or 59% of the initially identified titles and abstracts. The screening of such a large number of titles required the division of work among four reviewers. The decision to screen titles and abstracts together facilitated the screening process as well.

Much of the identified literature was excluded at the title and abstract level, resulting in 1441 (4%) articles selected for full text screening. Of the 1441 identified articles, we could not retrieve 319 (22%) articles, consisting mostly offline resources such as book chapters and technical reports. Furthermore, academic search

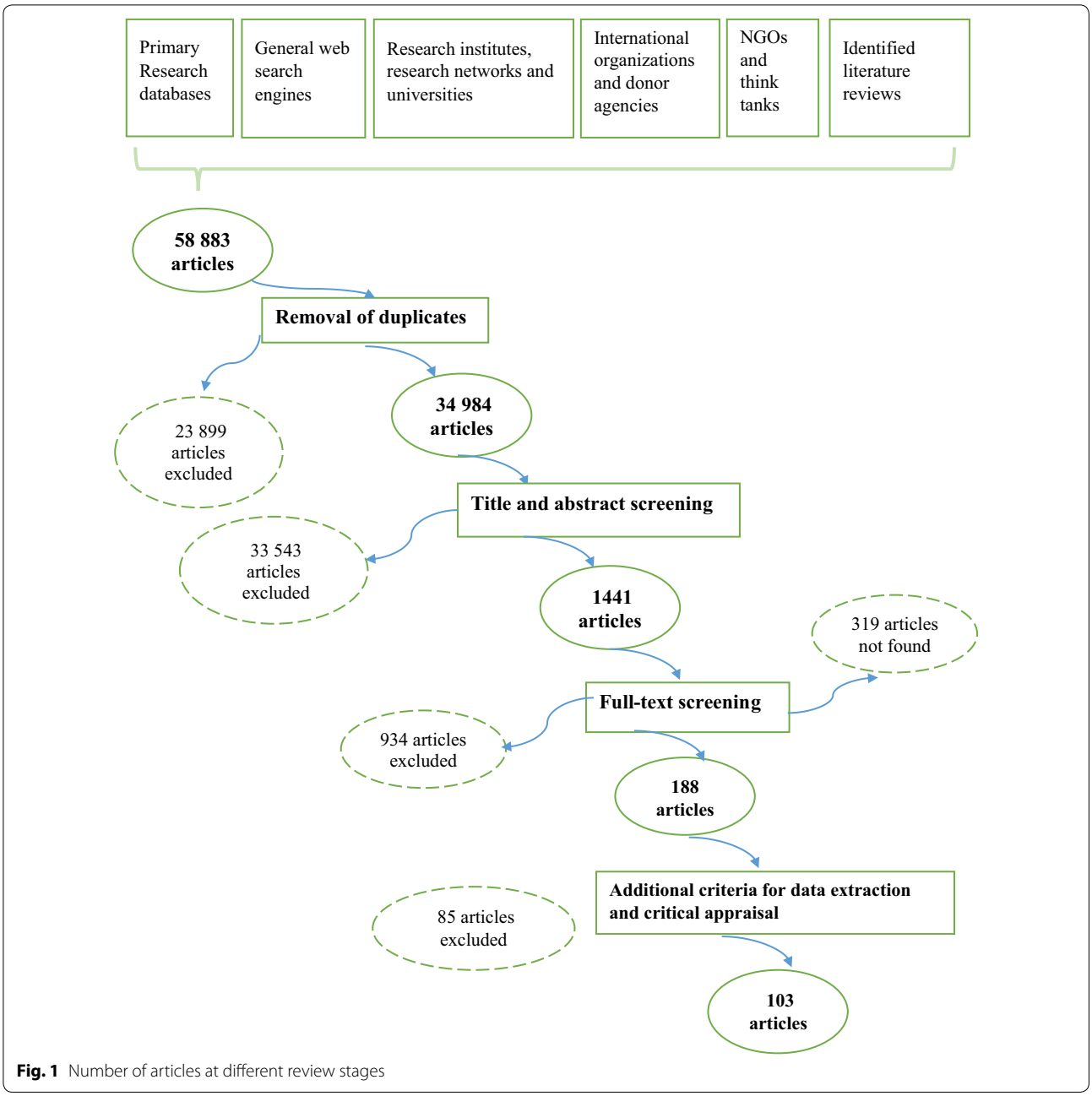

Fig. 1 Number of articles at different review stages

engines also identified literature for which we could not source full texts because of the lack of bibliographic detail (e.g. only author, title and abstract were given).

Of the 1122 articles screened at full text, we excluded 934 (83%) articles because they did not present quantitative or qualitative comparisons of environmental outcomes. A further 85 (8%) articles were excluded either because the bundle of rights approach could not be applied due to insufficient information or the article contained compound studies that could not be disaggregated (Additional file 5). In total, this review rejected a majority (99.7%) of the identified articles, and accepted 103 articles for data extraction and analysis. All articles included in data extraction are presented in the Additional file 6.

In total, 100 English language articles, two Spanish language articles and one French language article were included in the review. The research in these articles was conducted in 42 countries (Table 4). None of the Finnish language articles passed initial screening phases and none of the Indonesian references passed full text screening.

From these 103 articles, 374 studies were identified. Figure 2 presents the distribution of study numbers by resource system and geography. Of the 374 studies identified, 204 (55%) studies examined forests, followed by fisheries with 117 (31%) studies and rangelands with 53 studies (14%). Geographically, 145 studies were conducted in Africa (39%), followed by Latin America and the Caribbean with 120 studies (32%) and Asia with 109 studies (29%).

Figure 3 presents the same distribution as a function of the number of articles. Comparing Figs. 2 and 3 demonstrates that although the literature on forests and fisheries spanned the globe, the rangelands literature is highly concentrated to Africa, with South Africa accounting for the majority of studies (32 studies in 6 articles).

The most commonly studied property regimes were community (122 studies) and state regimes (113 studies) which together accounted for 63% of all the studies. Furthermore, there were several differences between how property regimes were compared in resource systems (Fig. 4). For example, in fisheries, most regimes were evaluated against open access, and only 11 studies did not involve an open access regime. Forest studies were dominated by comparisons between state and community regimes (89 studies or 24%), followed by comparisons between private and community regimes.

Table 4 Geographical location of the research (by article number)

Country	Number of articles
Tanzania	10
South Africa	9
Mexico	7
India, Nepal, Philippines	5
Brazil, Ethiopia, Indonesia, Solomon Islands	4
Ecuador	3
Belize, Botswana, Cambodia, Central African Republic, Colombia, Guatemala, Honduras, Kenya, Nicaragua, Peru, Seychelles, Tunisia, Uganda, Zimbabwe	2
Bhutan, Bolivia, China, Costa Rica, Fiji, Ghana, Grenada, Malaysia, Morocco, Panama, Papua New Guinea, Mozambique, St. Lucia, Thailand, Togo, Vietnam	1
Total number of articles	*103*

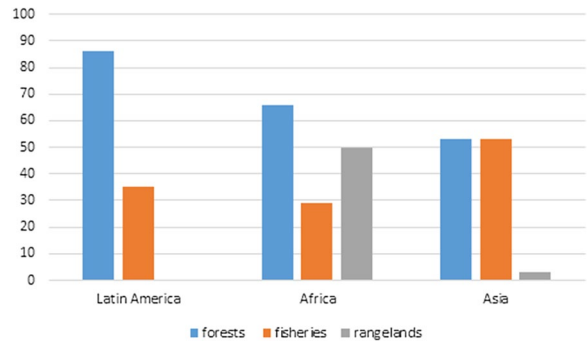

Fig. 2 Distribution of studies by resource systems and regions. The total number of studies was 374

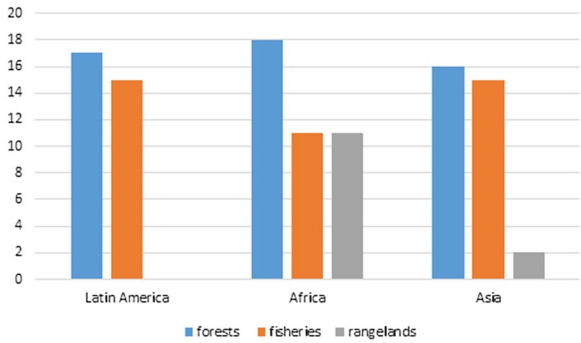

Fig. 3 Distribution of articles by resource systems and regions. The total number of articles was 103

The overwhelming majority of identified studies used case–control study designs (324 studies) comparing regime types (e.g. community rangeland compared with private rangeland), whereas only 50 studies included a before-and-after comparison. Of these, BACI study designs were most often used in fisheries studies (21 studies) and appeared rarely in forests and rangelands studies (Table 5). In all, only 26 studies used a BACI design.

Critical appraisal

Critical appraisal was conducted for individual studies but results were recorded under individual articles. Critical appraisal of the 103 articles included in the analysis found most studies (259 studies in 70 articles) fulfilled at least three out of the four quality criteria (Table 6), indicating considerable strength in the reliability of their findings. Three articles (consisting of 7 studies) met none of the four criteria [30–32], while 29 articles (consisting of 123 studies) met all the criteria (Additional file 9).

The majority of studies described their methodology in a clear and replicable manner (263 studies in 72 articles), used an appropriate methodology for answering the research question(s) posed (359 studies in 97 articles), and accounted for the presence of potential confounding factors (268 studies in 72 articles). The question regarding the clarity and potential replicability of the methods was assessed through six sub-criteria on the presentation of the research question, definition and selection of PICO criteria, discussion of biases and data sources, and

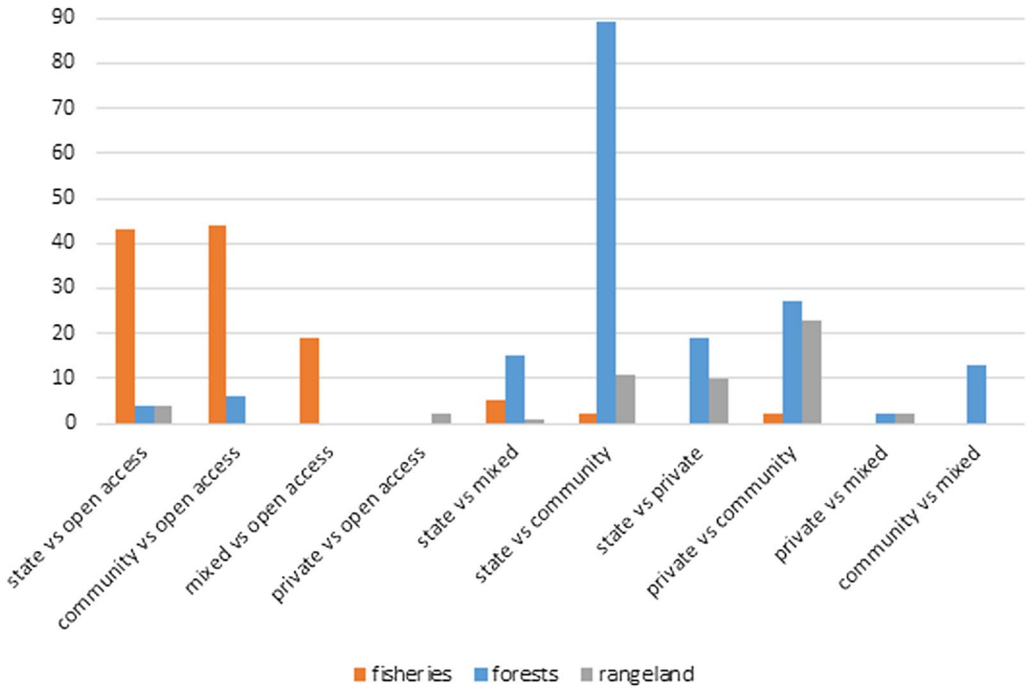

Fig. 4 Distribution of property regime comparisons by studies

Table 5 Distribution of studies by study design

	Forests	Fisheries	Rangelands	Totals
Case–control study (spatial)	185	89	50	324 (87%)
Before-after study (temporal)	16	7	1	24 (6%)
BACI study	3	21	2	26 (7%)
Total	204	117	53	374

Table 6 Distribution of articles and studies by number of criteria met

Number of criteria met	Number of articles (%)	Number of studies (%)
0	3 (3%)	7 (2%)
1	9 (9%)	35 (9%)
2	21 (20%)	73 (20%)
3	41 (40%)	136 (36%)
4	29 (28%)	123 (33%)

statement of study duration (Table 7). Besides confounding bias (the effects of potential confounding factors), other sources of bias were not well reported, reflecting a particular weakness in the evidence base.

Furthermore, half of all studies were found to have neither well-explained nor well-justified sampling selections (175 studies in 54 articles). However, this particular criterion was narrowly written and strictly applied (for instance, if the author didn't explain the difference between number of sample plots in control versus impact sites, this criterion was marked as not met), and therefore it was not used as a decisive criteria for exclusion.

The complete critical appraisal can be found in Additional file 7.

Contextual factors

In the review protocol, we outlined a procedure for coding the presence and extent of certain contextual factors that turned out to be impossible to complete during the review due to the limited data presented in many studies. As a result, we recorded information as it was reported in the article rather than on the basis of the original coding protocol.

Although the importance of contextual factors is emphasized in the literature [1, 33], many articles did not provide such contextual information (Fig. 5). The most commonly described contextual factors were the size of the area (57%), market demand (52%), enforcement (48%) and information on accessibility (33%), while clarity of rights was possible to identify in 32% of the studies. All other contextual factors were featured in less than 30% of the studies. For the data collected from external data sources, we were able to record Gini index for 34% of the studies and the Transparency International corruption

Table 7 Number of articles and studies meeting sub-criteria on clarity and replicability

Sub-criteria for clarity and replicability (question 1)	Number of articles	Number of studies
Is the research question clearly stated?	102 (96%)	368 (98%)
Is PICO defined?	77 (73%)	266 (71%)
Is selection process of PICO explained?	87 (82%)	328 (88%)
Is bias discussed?	39 (37%)	167 (45%)
Is data source mentioned?	100 (94%)	365 (98%)
Is study period stated?	89 (84%)	310 (83%)

index for 82% of the studies; however, the scores from the Transparency International could not be compared across years due to changes in methodology used to calculate them. In addition to these contextual factors, we were able to determine ecosystem type and protection status for all of the studies.

Contextual factors were more frequently presented by research that used mixed and social science methods than natural science methods. As Fig. 6 demonstrates, the literature on forests consisted to a large extent of mixed methods research, whereas natural science approaches dominated fisheries and rangelands research.

Following data extraction, the review team reexamined the initial hypotheses and contextual factors (Table 2) to determine how to deal with the lack of information in many data categories, as well as how to best analyze qualitative information recorded. We examined both our initial hypotheses and the data that was most frequently reported in the articles. This examination resulted in slight modifications of three initial hypotheses on the level of enforcement, market demand and clarity, and the stability and legitimacy of property rights.

Our initial hypotheses posited that a high level of enforcement would result in positive environmental outcomes. However, information coded under enforcement was ambiguous, as most data entries noted the presence or absence of monitoring actions. Therefore, we re-categorized the enforcement category as monitoring and enforcement systems, which includes patrolling, fencing, presence of a ranger station, or reports of infractions. Monitoring is a necessary part of enforcement as there cannot be enforcement if the authority is unable to know whether the rules are being respected or if the authority cannot catch infractions [34]. Using monitoring instead of enforcement also allowed the analysis to be based on specific actions taken rather than qualitative statements regarding the levels of enforcement.

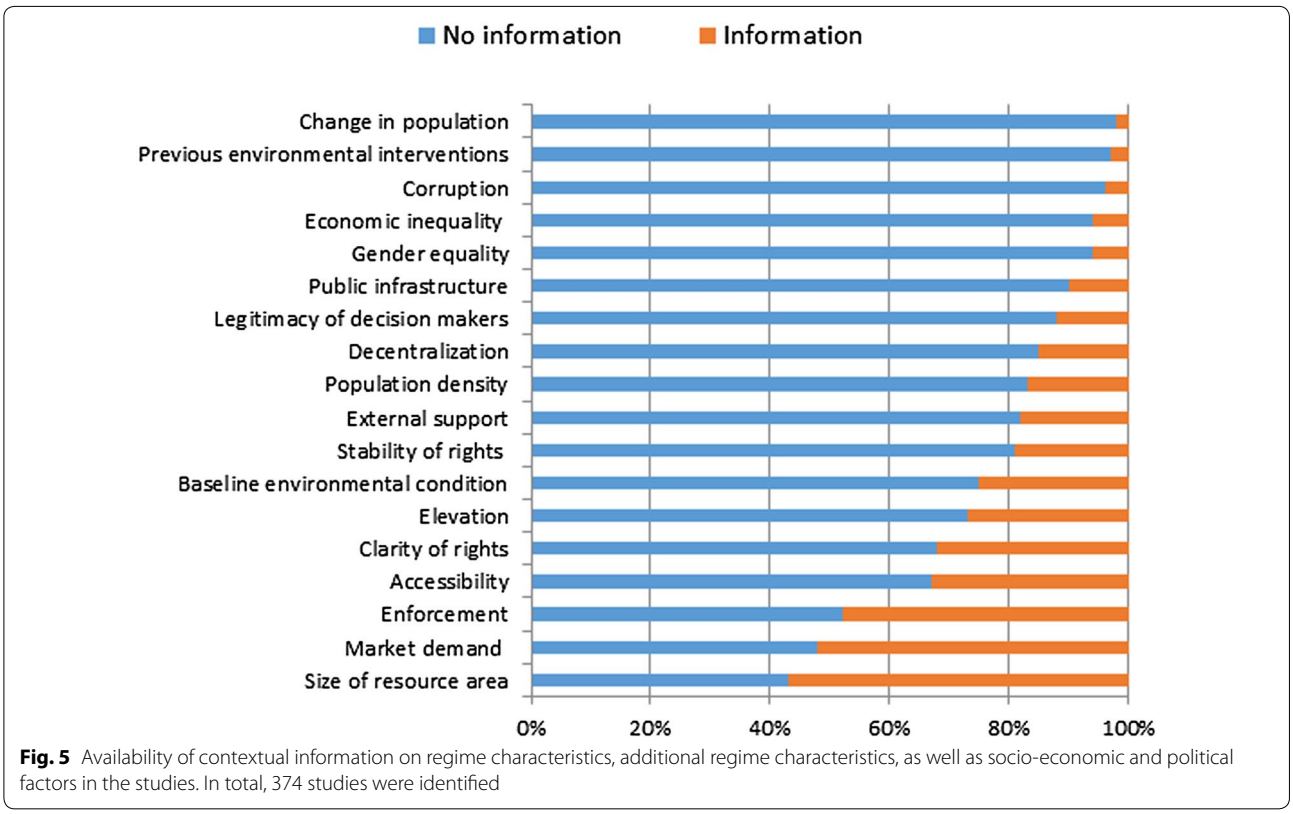

Fig. 5 Availability of contextual information on regime characteristics, additional regime characteristics, as well as socio-economic and political factors in the studies. In total, 374 studies were identified

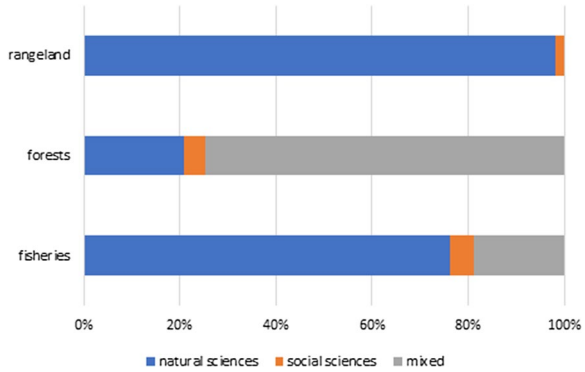

Fig. 6 Distribution of studies by research methods (study discipline) and resource type

The second variable that was changed was external market demand. Our hypothesis for market demand posited that greater use and resource demand would lead to negative outcomes. However, articles mostly described whether the resource used was for subsistence or for commercial purposes. Therefore, this category was re-categorized as degree of resource use, where subsistence use was categorized as low and commercial use as high, unless stated otherwise by the authors.

One of our initial hypotheses stated that the presence of clear, stable or legitimate rights would be related to positive environmental outcomes. In many studies, sufficient information was provided on either clarity, stability or legitimacy, but not all three variables. Therefore, we posited that the presence of any of the three variables would represent the presence of "positive regime characteristics." For example, if a study reported clear rights but did not report on stability and legitimacy [35], positive regime characteristics were noted as being present in the study. If unclear, unstable or illegitimate rights were reported, positive regime characteristics were noted as being absent.

For the narrative synthesis, we also included the variables of protection status, spatial extent (size), resource baseline conditions and the impact of time (Table 8). Analysis on the impact of ecosystem type, accessibility and elevation was limited by the diverse and inconsistent reporting of these variables. Although we were able to identify dominant ecosystems such as tropical and sub-tropical forests and dry forests, the studies in the evidence base were too dispersed across ecosystems to draw meaningful conclusions about their impact on environmental outcomes. Accessibility was mostly expressed in terms of distance (km) to nearest road or town, but without additional information, it was not possible to verify whether the resource was considered accessible or inaccessible (remote). Furthermore, although elevation was often reported, site-specific altitudes were frequently missing.

In analyzing the impact of time, we focused on the studies that included a temporal element (i.e. before-after study design and BACI study design) as well as studies using spatial comparison with multi-year data on environmental outcomes. We defined multi-year data to consist of studies that made measurements in more than 3 consecutive years. We also assessed the impact of time on outcomes in terms of the time elapsed between regime intervention year and the year when environmental outcomes were measured (study year).

Narrative synthesis

The critical appraisal rejected 251 studies (74 articles) and only 123 studies from 29 articles were included in the final synthesis. Due to the limited nature of available data, we were unable to undertake any quantitative data synthesis and instead we have provided a narrative synthesis on the reported impacts of contextual factors on environmental outcomes (Tables 9, 10, 11). Furthermore, Additional file 10 provides a summary of the environmental data that was used to determine environmental outcomes.

As we wanted to count study performance only once, we removed 53 overlapping results. In this way, if an article compared a community regime to a state regime, we counted only the comparison assessing community performance over state and removed the comparison assessing state performance over community. Figure 7 shows the distribution of the remaining 80 studies that were included in the narrative synthesis.

Results from forest resource systems

Overall, 47 studies fulfilled the critical appraisal criteria. These studies consisted of 28 comparisons made with state regimes and 19 comparisons with private regimes (Fig. 8).

Two studies compared state with open access, and the state reportedly performed better [36]. When compared with private and community regimes, the state was reported as performing better in 9 studies [35, 37, 38], while private and community regimes were reported as outperforming the state in 12 studies [35, 37, 39–42]. Four studies compared state performance with another state regime [43]. Here state-controlled national park and game controlled area were reported as performing better than forest reserve and open access regimes. Of the 19 studies that made comparisons with private regimes, 6 studies reported negative outcomes [35] and 12 studies reported undetermined outcomes (i.e. study reported both positive and negative outcome measurements) [39, 44]. In addition,

Table 8 Summary information on contextual factors considered

Former variable	New variable	Categorization
Level of enforcement	Presence of monitoring and enforcement systems	Yes
		No
		Missing (information)
Market demand	Resource use level	High
		Low
		Missing (information)
Clarity, stability and legitimacy of rights	Presence of positive regime characteristics	Yes
		No
		Missing (information)
Protection	No change	Yes
		No
Area of spatial extent	No change	The impact of size will be looked at individual study level
Baseline resource condition	No change	Good
		Fair
		Poor
		Missing
Study period	Impact of time	Length of data collection period
Year of regime introduction		Time elapsed between regime intervention year and the study year

one comparison with mixed regime also resulted with undetermined outcomes [45].

Looking at the results geographically, there were differences in reported state regime performance between regions (Fig. 9). In Latin America and Africa, state forests were associated with reported positive outcomes more often than community forests, while in Asia community regimes were more commonly associated with positive performance. All private regime comparisons with community regime were located in Latin America, while open access regimes were only reported in Africa.

Based on the analysis of reported contextual factors (Table 9), monitoring, protection, low resource use pressure and positive regime characteristics are more often associated with positive outcomes than with negative outcomes. Although 2 studies reported positive outcomes to be associated with non-monitoring [35] and high resource use pressure [41], no studies reported positive outcomes in the absence of positive regime characteristics [36, 45, 46]. Overall, the number of undetermined outcomes accounted for 28% of all the studies.

Results from fisheries resource systems

All 29 fisheries studies included a regime comparison with an open access situation (Fig. 10). All regimes (state, community and mixed) reported an association with positive outcomes (e.g. better coral cover or larger fish abundance) or neutral outcomes (e.g. similar coral cover or fish abundance) compared with open access (Fig. 10), except for 2 studies with undetermined outcomes [47, 48]. There were more reported studies of state regime performing similarly to open access [49–53] than community performing similarly to open access [54]. Moreover, Latin America saw more studies of state regimes reportedly performing similarly to open access regimes than Asia and Africa combined. All community regime studies were in Asia.

Table 10 shows that better or neutral outcomes compared with open access were reported when state, community or mixed regimes reported the presence of monitoring, protection, and low resource pressure. In fact, there were no studies that reported positive outcomes in the absence of monitoring or protection, similarly, no studies with positive outcomes reported high resource use pressure. In two studies [50], similar performance with open access was reported in the absence of monitoring and high resource use pressure. Overall, regime characteristics were not broadly discussed, and we noted only three studies [51, 55, 56] that discussed positive regime characteristics.

Results from rangeland resource systems

After critical appraisal only 4 rangeland studies were eligible for further analysis [57, 58]. These 4 studies compared private rangelands to communal rangelands, with 3 private regimes associated with positive outcomes and 1 private regime with undetermined outcomes (Table 11). The resource use pressure in these studies referred to stocking rates, reflecting the number and type of animals per unit area.

Resource size as a contextual factor

The analysis on the effect of fishery size was limited due to the missing values, as size was reported in only 16 studies. The majority (9 studies) reported positive outcomes, but fishery areas ranged from small to large (0.5 ha −930 km^2) Forest area were reported in almost all the studies (40 out of 47). Although there was no overall correlation reported between size and environmental outcomes, the studies that reported smallest forest areas also reported negative or undetermined outcomes [38, 46].

Time as a contextual factor

To assess the impact of time on reported outcomes, we first assessed the length of data collection periods. Most of the evidence is based on 1–3 year measurement periods (Fig. 11). Out of the 80 studies included in the

Table 9 Reported effects of contextual factors across property regimes in forests

Property regime	Citation number and article title	Reported outcome (compared to state)	Contextual factors						
			Monitoring		Resource use pressure		Protected area		Positive regime characteristics
			Yes	No	Low	High	Yes	No	Present/absent
Comparisons with state regime									
Community	Nautiyal and Kaechele [37]	Positive					x		Present
Community	Nautiyal and Kaechele [37]	Positive					x		Present
Community	Nautiyal and Kaechele [37]	Neutral					x		
Community	Nautiyal and Kaechele [37]	Negative					x		
Community	Hayes [39]	Positive	x					x	Present
Community	Lambrick et al. [40]	Positive	x		x			x	Present
Community	Måren et al. [41]	Positive				x		x	
Community	Sudtongkong and Webb [42]	Positive	x		x			x	Present
Community	Sudtongkong and Webb [42]	Positive	x		x			x	Present
Private	Vuohelainen et al. [35]	Positive	x		x		x		
Private	Vuohelainen et al. [35]	Positive	x		x		x		
Private	Vuohelainen et al. [35]	Positive	x		x		x		
Private	Vuohelainen et al. [35]	Positive		x	x		x		
Private	Vuohelainen et al. [35]	Positive	x		x		x		
Private	Vuohelainen et al. [35]	Negative				x	x		
Community	Vuohelainen et al. [35]	Negative	x			x		x	Present
Community	Vuohelainen et al. [35]	Negative				x		x	
Community	Vuohelainen et al. [35]	Negative				x		x	
Open access	Hammi et al. [36]	Negative		x	x			x	Absent
Open access	Hammi et al. [36]	Negative		x	x			x	Absent
Community	Bossart et al. [38]	Negative	x				x		
Community	Bossart et al. [38]	Negative	x				x		
Community	Bossart et al. [38]	Negative	x				x		
Community	Bossart et al. [38]	Negative	x				x		
Comparisons with private regime									
Community	Vuohelainen et al. [35]	Negative	x			x		x	Present
Community	Vuohelainen et al. [35]	Negative				x		x	
Community	Vuohelainen et al. [35]	Negative				x		x	
Community	Gibson et al. [44]	Undetermined	x					x	Present
Community	Gibson et al. [44]	Undetermined		x				x	Present
Community	Gibson et al. [44]	Undetermined		x				x	Present
Mixed	Rai and Uhl [45]	Undetermined		x		x		x	Absent
Community	Tucker [46]	Undetermined	x			x		x	Absent
Community	Tucker [46]	Undetermined				x		x	Absent
Community	Tucker [46]	Undetermined				x		x	Absent

x presence, *empty cell* study did not have the information

synthesis, 34 studies had multi-year data (where data collection spans at least three consecutive years). We found more undetermined outcomes from studies with shorter data collection durations, however all the studies with undetermined outcomes originated from one article [46].

Differences between short and long-term impacts were examined in two different contexts. First, we examined whether the similar outcomes reported with open access might be associated in the literature with short timespans since the introduction of new tenure regimes. The regime introduction year was missing in 8 studies, leaving 21 fisheries property regimes for this analysis. For studies with positive outcomes, the difference between regime intervention year and environmental data collection

Table 10 Reported effects of contextual factors across property regimes in fisheries

Citation number and article title	Reported outcome (for state)	Contextual factors						
		Monitoring		Resource use pressure		Protected area		Positive regime characteristics
		Yes	No	Low	High	Yes	No	Present/absent
Comparisons between state and open access								
Götz et al. [70]	Positive					x		
Kamukurua et al. [71]	Positive	x				x		
Walmsley and White [51]	Positive	x				x		
Mayfield et al. [52]	Positive					x		
Mayfield et al. [52]	Positive					x		
Camargo et al. [49]	Neutral					x		
Shank and Kaufman [50]	Neutral		x		x	x		
Shank and Kaufman [50]	Neutral	x			x	x		
Walmsley and White [51]	Neutral	x				x		Absent
Mayfield et al. [52]	Neutral					x		
Mayfield et al. [52]	Neutral					x		
Lopes et al. [53]	Neutral					x		
Comparisons between community and open access								
Walmsley and White [51]	Positive	x				x		
Cinner et al. [72]	Positive					x		
Clements et al. [73]	Positive			x		x		
Clements et al. [73]	Positive			x		x		
Clements et al. [73]	Positive			x		x		
Aswani and Sabetian [56]	Positive					x		
Aswani and Sabetian [56]	Positive					x		Absent
Aswani and Sabetian [56]	Positive					x		
Halpern et al. [54]	Neutral	x		x		x		
Halpern et al. [54]	Neutral	x		x		x		
Halpern et al. [54]	Neutral	x		x		x		
Yasue et al. [48]	Undetermined	x			x	x		
Comparisons between mixed and open access								
Francini-Filho and Mourab [55]	Positive	x		x		x		Present
Walmsley and White [51]	Positive	x				x		
Shank and Kaufman [50]	Neutral		x		x	x		
Silvano et al. [74]	Neutral			x		x		
Yasue et al. [47]	Undetermined	x			x	x		

x presence, *empty cell* study did not report the information

Table 11 Reported effects of contextual factors across property regimes in rangelands

Citation number and article title	Reported outcome for private regime	Monitoring		Resource use pressure		Protected area		Positive regime characteristics
		Yes	No	Low	High	Yes	No	Present/absent
Comparisons with community regime								
Kinnaird and O'Brien [58]	Positive	x				x		
Kinnaird and O'Brien [58]	Positive	x				x		
Kinnaird and O'Brien [58]	Positive	x			x		x	
Bennett et al. [57]	Undetermined				x		x	

x presence, *empty cell* study did not have the information

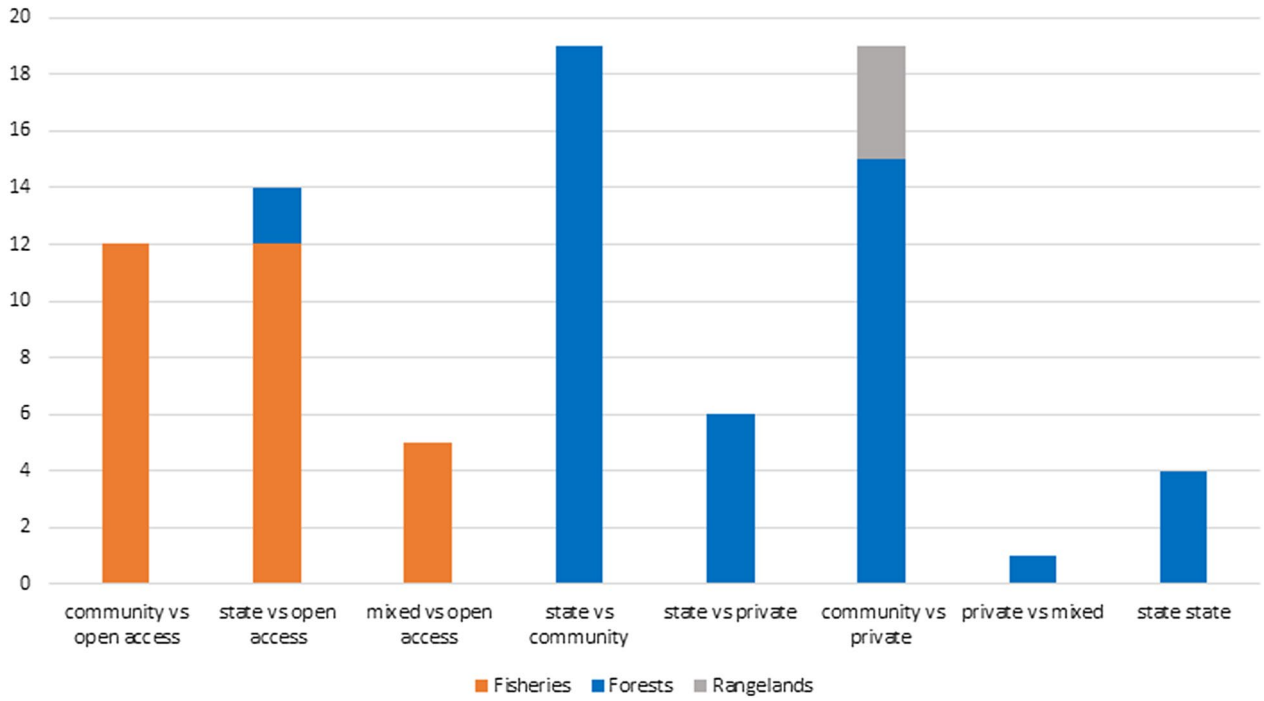

Fig. 7 Distribution of property regime comparisons in the narrative synthesis by study numbers. The narrative synthesis consisted of 80 studies

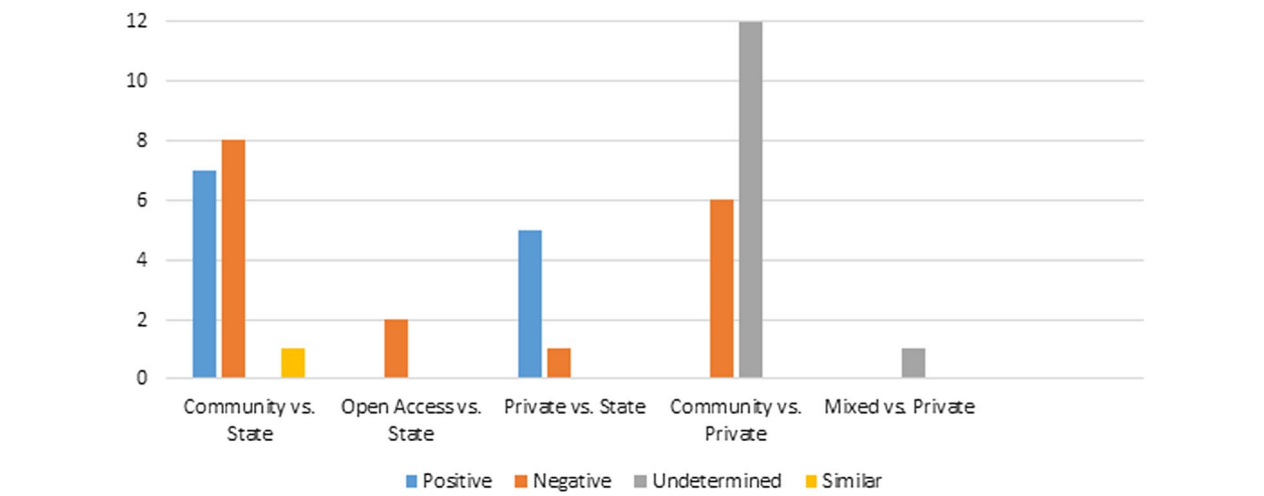

Fig. 8 Relative reported performance of property regimes in forests by study numbers. The first three groups present outcomes for property regime comparisons with state regime (24 studies) and the last two groups present the outcomes for property regime comparisons with private regime (19 studies). The comparison between state and state regime is not featured

years was 4–14 years (median 9 years, SD = 4.9), while for the studies with neutral outcomes it was 4–29 years (median 10 years, SD = 8.4).

Second, we also assessed how time affected studies that saw changes in property regimes (i.e. before-after and BACI study designs). There were six such studies, although one of the studies did not provide clear information on the regime intervention year [57]. Of the five remaining studies, regime shifts were reported as leading to positive outcomes in four studies [51, 55], while one study saw an undetermined outcome [47]. In the studies with positive outcomes, the time difference since regime

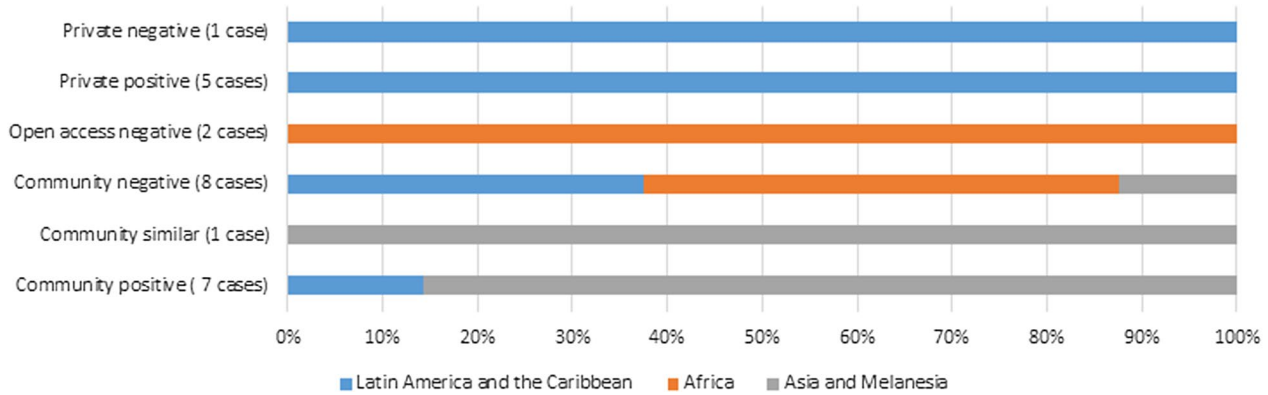

Fig. 9 Distribution of forestry studies and reported outcomes across regions. All the comparisons are made with state regime. The comparison between state and state regime is not featured

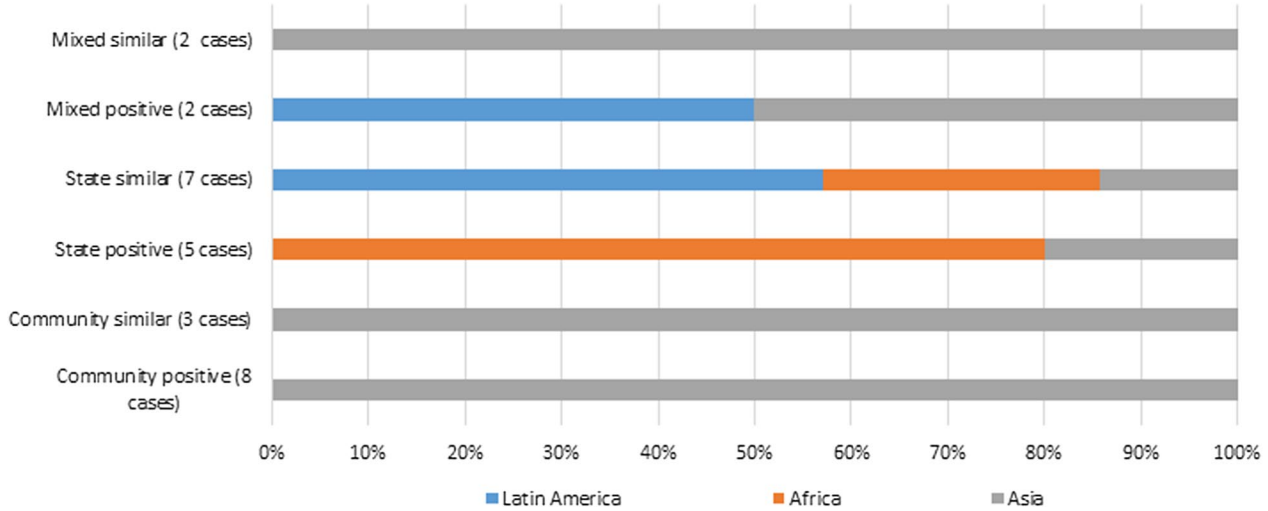

Fig. 10 Distribution of fisheries studies and outcomes across regions. All the comparisons are made with open access regime. The two studies with undetermined outcomes are not featured in the figure

intervention and environmental data collection ranged from 4 to 14 years. All four studies reporting positive outcomes shifted from open access to mixed regimes, and thus the direction of the regime shift (from unmanaged to managed) could have also negated the influence, if any, of time since regime change.

Resource baseline condition as a contextual factor

We could not often determine baseline resource condition as the majority of studies were spatial comparisons that did not present sufficient information regarding initial environmental conditions. Only 16 studies reported enough baseline data [36, 40, 41, 44, 46, 47, 51, 55, 56] and these were classified into poor, fair and good conditions (Fig. 12). The associated environmental outcomes consisted of 8 studies with positive outcomes and 7 studies with undetermined outcomes. The dominance of poor baseline condition in fisheries is likely because four studies assessed change in environmental outcomes from an open access situation to managed regime.

Discussion

Reasons for heterogeneity

The analysis of contextual factors reported in the literature was limited by the extent of missing information on contextual variables. An alternative data extraction approach is to note whether a context variable is absent or present (similar to [26]); however, this approach may not reveal whether contextual factors are missing because of 'true' absenteeism (absence of a factor in the study site) or because information was not collected. The reporting of contextual data was also highly diverse; for example,

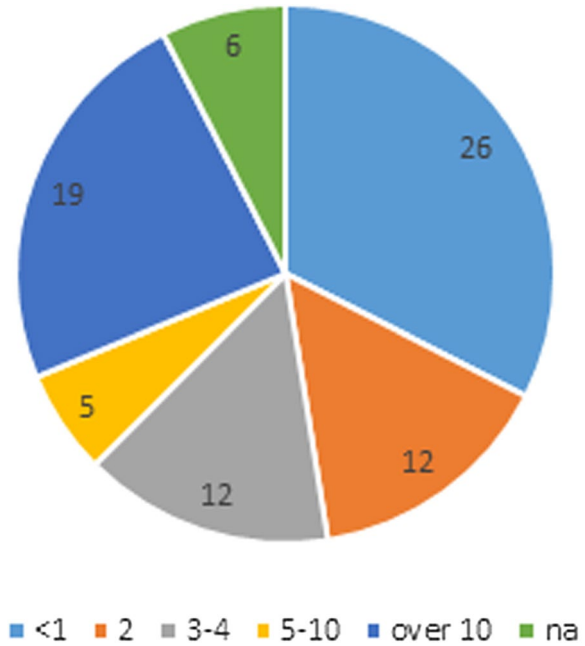

Fig. 11 Number of studies and the length of environmental data collection periods in years. *na* not available

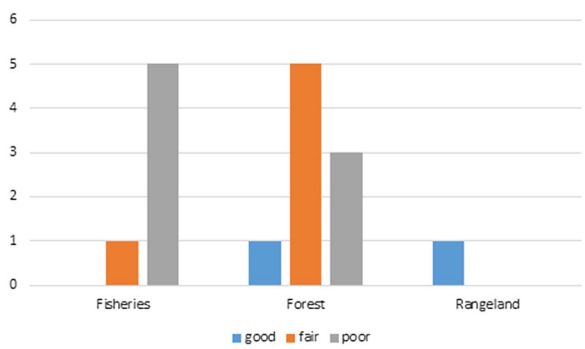

Fig. 12 Initial resource condition

data on population size was variously reported in terms of the number of individuals, households or described qualitatively, which restricted the possibilities for further analysis.

The evidence base is dominated by studies of resource systems in protected areas created with environmental conservation objectives. The conservation objective was especially pertinent in fisheries, where all the studies included in the narrative synthesis consisted of comparisons of protected areas with non-protected area (property regime to open access area). The aim of the protected area is to conserve resources and limit the resource use in the area, and thus formal protection may have outweighed the impacts of property regime. Similarly, if a local community is denied access to the state forest that they traditionally have depended on, they will likely shift their consumption to resources that are available to them (in this case community forest) [59].

Property regime outcomes can differ based on the scope of environmental measurements used. If environmental condition is based on relatively few indicators (e.g. rate of deforestation, occurrence of butterfly species), important aspects of environmental quality will remain undetected. For example, the outcomes between property regimes may differ whether studies examine small or large mammals [60] or rely on quantitative rather than qualitative data [61].

Review limitations

Our analysis used Schlager and Ostrom's [20] framework for regime descriptions. Most studies mentioned only a few of the rights in the bundle, while studies that provided detailed descriptions of property regimes were often categorized in the single category of mixed property regimes as different rights were held by different actors. Additionally, authors defined terms and concepts in disparate ways, as previous work on property regimes has noted [14]. The terminology is especially varied in the forestry literature, where village lands, sacred forests, 'ejidos' and joint forest management could all characterize forms of community resource management. Likewise, in fisheries, open access is an ambiguous term that may elide the particular rules and rights held and practiced on-site.

We sought to minimize reviewer bias by checking consistency of interpretation of our inclusion criteria, our critical appraisal and data extraction criteria through kappa analysis at different stages as well as through continuous consultations among reviewers when differences of interpretation emerged. Despite our efforts to reduce the risk for individual perception bias, especially regarding the classification of environmental outcomes, we cannot rule it out completely. We also recognize the well-known bias toward positive outcome reporting but this review could not clarify to what extent publication bias is present in the included articles. Although we found many studies reporting positive outcomes (especially in fisheries), also neutral and undetermined environmental outcomes were reported.

A further limitation of this review was the significant amount of missing information on contextual factors of interest in the identified studies. We concur with Yin [62], who highlighted the knowledge gaps that exist in terms of quantity and quality of the evidence. This seriously undermined our ability to test the external validity of identified studies.

Finally, we note that future reviews in this area would do well to take advantage of new approaches and technologies. Our review, which required major investment in time and human capital, ultimately only yielded a small number of relevant studies even as initial searches suggested more than 50,000 might be relevant. Machine learning and other technological methods are increasingly available to aid in systematic reviews at the title and abstract and full text stages [63] and other approaches are now available to help use a broader range of datasets (e.g. Google Scholar) [64]. Future work in this area can be streamlined through use of these and other emerging methods.

Review conclusions

This review is, we believe, the first of its kind to systematically explore environmental outcomes across resource systems, property regimes and regions. Owing to the limited nature of an evidence base that met our selection and inclusion criteria, the unequal distribution of resources and regimes within the articles reviewed; and methodological limitations noted above, we were unable to undertake the ambitious analysis we had set ourselves in the protocol. Indeed, insufficient data quality and completeness are two of the major findings from our search, which limited our ability to answer the overall question of our review regarding the environmental impacts of different property rights regimes.

The evidence base is overwhelmingly dominated by forestry and fisheries, with very few robust studies about rangelands. There was also unequal distribution of property regimes studied in the evidence base: forest and rangeland studies made comparisons between state, community and private regimes, whereas the majority of fisheries studies compared protected areas with open access regimes. The notion of open access is widely challenged in the common property literature [65] and detailed examination of any given study may uncover customary rules regarding the resource use. The evidence base is also dominated by study design using a case control comparison; information on the baseline conditions of resource systems is extremely limited. If the baselines for spatial comparisons are not carefully examined and reported, there is a risk that divergent environmental outcomes may be largely due to pre-existing conditions rather than regime interventions.

Our review findings have been derived from tabulations of the reported outcomes in the primary literature. The contextual factors that we were able to use in our narrative synthesis consisted of the status of protection, resource use pressure, monitoring and positive regime characteristics. Although the importance of these variables has been underscored in previous literature, our review highlights the following findings: in fisheries, all the reported positive outcomes were associated with presence of monitoring, protection or low resource use pressure. For forestry studies, the results were mixed and the presence of the monitoring, protection and type of resource use pressure may not necessarily have determined the outcomes. The difference might be due to the specific characteristics that make monitoring and protection successful in each area and to the degree to which high resource use conflicts with sustainable resource use. Overall, robust analysis is also complicated by the relatively high number of studies reporting undetermined outcomes.

Most previous reviews have examined community forestry areas in relation to non-community forestry areas [66–68] and thus have been less specific about the nature of the comparison regime than our review. Similarly, evidence synthesis in fisheries is largely limited to assessments of performance of marine protected areas and co-management regimes with different counterfactuals (different comparison regime) [69]. For rangelands, we found no review synthesis with which to compare our findings.

Implications for policy and management

The formalization of property rights over natural resources, including property rights devolution from state to communities and private individuals, comprises a major policy instrument for those seeking to advance sustainable resource management. This review did not find adequate data or robust evidence to make conclusions about the strength of the relationship between property rights devolution or regime changes and resource conservation outcomes. Contextual factors obviously affect environmental outcomes and resource conditions; on the other hand, the complex web of interactions between different factors makes determination of relationships between a particular factor and outcomes difficult. For improved understanding on what works, when and for whom, greater funding for long term assessments of property regime interventions is required, as some measure of monitoring and evaluation should continue even after main program activities have concluded.

We caution the readers not to use this review's results as an indicator how well specific regimes are performing in different parts of the world. Although the review identified distinctive differences in regime performance, such as the state forestry regime reportedly performing better than community regime in Latin America and Africa but not in Asia, these results are based on a very limited sample (2 articles for Latin America, 1 article for Africa and 4 articles for Asia).

Implications for research

Property rights regimes are inherently complex and coding regimes into five different categories (state, community, property, mixed and open access) presents a simplification of social relations among different actors. Even though we aimed to capture the nuances of the rights by recording the bundle of rights (access, withdrawal, management, exclusion, alienation), important aspects were left unrecorded, especially regarding how the decision-making rights were shared in mixed regimes. Although the bundle of rights is a useful analytical tool and has systematized the way tenure and property rights regimes are described, its retrospective application to published studies is very challenging. We recommend that any subsequent analysis applying the bundle of rights framework to a published study would seek additional information regarding the property regime to cross-check interpretations of the bundle of rights.

Similarly, categorizing environmental outcomes into four categories (positive, negative, neutral and undetermined) is a simplification and may obscure important nuances especially when the scope of environmental measurements made is limited. Our recommendation for future researchers is to improve and nuance this type of analysis. In our opinion, an assessment of the environmental outcomes should also include information on the regenerative capacity of the resource. Although this type of analysis is conducted to certain extent, this kind of information would be very useful as an indication how likely the current environmental outcome is in the future.

Many studies included in this review had very limited information on contextual factors. Although increased reporting is one solution, however, acknowledging the realities of academia which favour abundant publishing, we call for researchers to focus foremost on their initial study design. Although the use of multidisciplinary methods is increasing, future empirical research on property rights impacts would also benefit if natural scientists would collaborate with social scientists to consider and report on property regime characteristics and socioeconomic contextual factors. Likewise, teams led by social scientists would benefit by collaborating with natural scientists to generate more rigorous empirical data on environmental outcomes.

Currently, the evidence-base is not representative of property regimes comparisons globally, as much of the research is conducted in a few selected countries (e.g. Tanzania, South-Africa and Mexico). The evidence-base should be expanded in terms of new regions, especially in the rangelands literature which was largely absent outside of Southern Africa. The overall evidence-base would also be enhanced if the fisheries literature expanded the regime comparisons beyond open access situations.

Additional files

Additional file 1. Glossary of resource systems.

Additional file 2. Variances between search outlined in the review protocol and the systematic review.

Additional file 3. Description of detailed search in different databases by search terms and strategies.

Additional file 4. List of developing countries.

Additional file 5. List of articles that did not meet additional inclusion criteria.

Additional file 6. List of articles that met the additional inclusion criteria and were selected for critical appraisal/data extraction.

Additional file 7. Critical appraisal of studies.

Additional file 8. Data extraction sheet.

Additional file 9. Articles included for the narrative synthesis.

Additional file 10. Summary of environmental data and environmental indicators used to determine environmental outcomes.

Authors' contributions

MO, DM, WZ, BM, GP and Esther Mwangi designed the research. MO & WZ conducted pilot research. The screening, critical appraisal and data extraction was supervised by MO, conducted by MO and SH, together with a consultant reviewers with fisheries expertise (Jensi Sartin) and forestry expertise (Louis Durey). Additional support in screening was provided by WZ, DM and BM. WZ performed the analysis on critical appraisal, while MO performed the data analysis on the impact of contextual factors. MO and WZ wrote the review, with feedback and comments from DM, GP, SH and BM. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

See Additional files 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 for datasets.

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