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Abstract: Conservation actions generally benefit some groups more than others, and this inequity is thought to affect the probability of achieving conservation objectives. This has led to the common assumption that triple bottom line solutions -- those that are effective, efficient, and equitable -- are best and most likely to achieve each individual objective. Although this may be true, it has been little tested, and importantly lacks a conceptual foundation for understanding, predicting and evaluating how equity affects conservation outcomes. We describe types of equity relevant to conservation and explore how they may affect the probability of successfully achieving conservation outcomes. Depending on the equity type and context, the relationship between equity and conservation success varies. We find that the best conservation outcome is often achieved without perfect equity; highlighting the risk of ignoring the relationship between equity and success. We offer a conceptual foundation for better addressing this important issue in future research and application.

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

2 September 2015

DearEditors,

Re: Submission to Global Environmental Change

We are pleased to share a revised manuscript that addresses minor edits from two reviewers. We are grateful for their further refinements. We have attached a separate detailed response to reviewers.

For a long time it has been recognized that conservation actions that disproportionately impact the disenfranchised few –termed environmental injustice in the resource management literature – are both morally wrong and less likely to achieve ultimate desired outcomes. The interest in these topics has recently grown dramatically with the heightened attention given to global inequity across many aspects of society, including wealth distribution, climate change impacts, and others. What has been missing from this research and debate is a more complete assessment of how equity in general, across the entire spectrum of equity that ranges from severe injustice to perfect equity, affects the probability of success in achieving the desired environmental management outcome.

Here we tackle this issue within the realm of conservation science by developing and evaluating a formal conceptual foundation for assessing social equity. In particular, we highlight several key lessons and guidelines about how best to address the issue of equity in conservation planning:

- Equity is an increasingly important issue to address in conservation, yet a poorly articulated concept in most of the literature. We developed a conceptual foundation for understanding and evaluating equity within conservation that will help make this science and its application much more rigorous.
- In most cases there is a tradeoff between achieving conservation outcomes and producing equitable solutions – sometimes a strong tradeoff. We offer a formal way of calculating and addressing this tradeoff.
- Triple-bottom line solutions – those that achieve conservation outcomes effectively, efficiently, and equitably – may be quite rare.Acknowledging (and further testing) this result could profoundly change the nature of conservation actions.

Formal evaluation of equity in conservation has only just begun. Our work poses as many questions as it tries to resolve. We anticipate it serving a foundational role in guiding future research addressing this globally important management topic.

If additional information is needed, please do not hesitate to contact me.

Yours sincerely, on behalf of all co-authors,

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100 YEARS AHEAD

***Title page (with author details, acknowledgements or affiliations)**

Social equity and the probability of success of biodiversity conservation

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September 1, 2015

Dear Editors,

We are pleased that our manuscript has been accepted following further revision. We have slightly revised the final manuscript to address the two minorcomments from the reviewers. Below we detail our responses to each comment, with the original comment in **bold** and our response in regular font.

Reviewer #1:

The final minor amendment I would recommend relates to their response comment that they have identified whether they are discussing input or output equity in each examples in Section 3.

Response: We have clarified in the subsections (3.1-3.4) whether the examples described relate to input or output equity. (Edits are within lines 179-182; 193; and 235).

Reviewer #2:

There is one point that I think they have not got yet. It does not preclude publication - for as the authors observe, many people do not get it But they could draw attention to this more explicitly, the text they wrote in their response to me would suffice.

Response: We have added further justification for our belief that different values of equity might be comparable. See Line 311:

> "Not all perceived values of conservation (associated with either costs or benefits) will be tangible or easily quantifiable; yet assessing their relative importance has merit. Any type of equity in principle could be measured subjectively on a unitless scale of low to high. Formalization of problems that involve values can be an anathema to some, but the benefits of explicating integrating these issues into formal conservation planning are greater than ignoring perceived values altogether."

Highlights:

- Social equity, economic efficiency and environmental effectiveness are often sought
- Social equity can be necessary for success, but can compromise other goals
- We enhance our understanding of the social equity-conservation success relationship
- The best conservation outcome is often achieved without perfect social equity

Social equity and the probability of success of biodiversity conservation

Running Title: Social equity and conservation success

Abstract

Conservation actions generally benefit some groups more than others, and this inequity is thought to affect the probability of achieving conservation objectives. This has led to the common assumption that triple bottom line solutions -- those that are effective, efficient, and equitable -- are best and most likely to achieve each individual objective. Although this may be true, it has been little tested, and importantly lacks a conceptual foundation for understanding, predicting and evaluating how equity affects conservation outcomes. We describe types of equity relevant to conservation and explore how they may affect the probability of successfully achieving conservation outcomes. Depending on the equity type and context, the relationship between equity and conservation success varies. We find that the best conservation outcome is often achieved without perfect equity; highlighting the risk of ignoring the relationship between equity and success. We offer a conceptual foundation for better addressing this important issue in future research and application.

Keywords

Biodiversity, benefits, conservation planning, costs, environment, equity, triple bottom line

1 Introduction

Social equity - the equitable distribution of costs or benefits between individuals or groups of people - is a highly sought after ideal in many aspects of society. Whether related to education, employment, or healthcare, equitable outcomes or opportunities can influence the creation, durability, and success of local, national, and international policies (Solar and Irwin 2007). The conservation of biodiversity is no exception (Halpern *et al.* 2013). In contrast to health and education, however, relatively little work has been done to understand how, and in what cases, explicit consideration of equity influences effectiveness of a conservation plan or policy (henceforth 'conservation intervention', which can include, but is not limited to: protected area plans/policies, payments for ecosystem services plans/policies, etc.). Here we aim to enhance our understanding of the relationship between different types of social equity and success in biodiversity conservation interventions, with the goal of improving conservation outcomes. A rich body of literature exists on measuring the effectiveness of conservation interventions, and understanding factors affecting the probability of their success (Bottrill and Pressey 2012; Ferraro and Hanauer 2014; Mascia *et al.* 2014). Success in conservation is broadly defined by achievement of stated goals, which vary according to different values and beliefs. For example, a successful protected area plan could be measured by ecological representation, biodiversity persistence, or economic impact (Parrish *et al.* 2003; Klein *et al.* 2010), whereas a successful conservation policy could be measured by improved strength of legislation governing the use of natural resources (Gleason *et al.* 2010) or community support (Russ and Alcala 1999). Other conservation outcomes might be measured by changes in social, institutional or human capital (Bottrill and Pressey 2012; Ban *et al.* 2013). Ultimately, the success of conservation interventions is often evaluated on the basis of conservation benefit, social equity, and economic return, the three components to triple bottom line conservation outcomes (Halpern *et al.* 2013). Yet the feasibility of achieving such triple bottom line solutions, and the potential interactions and tradeoffs among the three components, remains largely untested. Halpern *et al.* (2013) found that social equity can compromise achieving efficient conservation outcomes, but highlighted the importance of further research focused on exploring how the relationship between social equity and conservation success might influence these trade-offs, in particular with respect to the many different types of equity. Here, we explore this relationship to provide insight to outstanding questions in conservation, including: Is probability of conservation success actually optimized when all three components are maximized? Or, does conservation success require approaches that deviate from the triple bottom line?

Equity is increasingly recognized as a component of conservation success (Ban *et al.* 2013; Campese et al. 2009). However, there are multiple types of equity (Figure 1), and being clear about what type of equity is important and being measured is critical for understanding the relationship between conservation success and equity. Equity concerns can arise from both internal factors (e.g., composition of the project team), which tend to be within the control of the planning team, and external contextual factors (e.g., social, geographic or economic conditions of the planning region), which are generally beyond the control of the project. For example, the design of a stakeholder engagement strategy might consider equal participation of different groups in a consultation process designed to ensure representation from all affected stakeholders, an internal factor. Alternatively, the variation and spatial distribution of existing income levels in the planning region might determine which populations or communities are affected by restrictions on resource use recommended by a conservation plan, an external contextual factor. While external factors can rarely be controlled, understanding, anticipating and managing their influence on the design and implementation of a conservation intervention is likely to increase its probability of success (Berkes 2004; Solar and Irwin 2007). Internal factors can be inputs into, and/or outcomes of, a conservation intervention, and can influence its success (Figure 1). We believe that consideration of different types of equity improves the chance of achieving conservation success.

The focus of this manuscript is on how social equity, one of many potential conservation objectives and factors affecting conservation success, influences the probability a conservation intervention succeeds in meeting its stated goal. We acknowledge that cases exist where equity plays little to no role in conservation interventions and their success, for example when governments impose protected areas despite local protests (Brockington 2004), but our emphasis here is on cases where equity matters. We identify different types of input and outcome equity and discuss their possible relationships with conservation success. Finally, we simulate how understanding these relationships can help us evaluate the feasibility of triple bottom line solutions, where social equity, environmental benefit, and economic return are maximized.

2 Social equity in conservation

A complex collection of social structures, economic systems, and policy frameworks determine the relevance of equity to conservation outcomes, and thus conservation success. These social determinants of conservation equity reflect the distribution of wealth, power, and access to resources within a society, and can in turn have different consequences for different types of conservation equity. We identified many types of conservation equity, and divided them into two main categories, input and outcome, that influence conservation success (Figure 1), all of which can be influenced by socioeconomic and political context (described below in section 2.1).

Several types of equity can be either input or outcome equity, or both, depending on the decision process and goals of the conservation action. The primary distinction is whether the type of equity is a dimension of the social context that influences the process of making a conservation decision, i.e., input equity, or is something affected by the conservation action, i.e., outcome equity. As such, potential metrics of these types of equity are often the same (Fig. 1b), but how they are used and interpreted will differ. Differences between input and outcome equity are further explained and illustrated below.

2.1 *Socioeconomic and political context*

Context variables encompass a broad set of structural, cultural, and functional aspects of a social system that exert a powerful formative influence on patterns of social stratification and, thus, influence conservation equity (Ostrom 1990; Solar and Irwin 2007). Fully characterizing all components of context is beyond the scope of this paper. Context determinants are often beyond the control of a conservation intervention, representing external factors influencing conservation success, except when the goal of the intervention is to change existing governance structures or policies. We highlight context here because it influences equity and thus affects conservation success. Examples of determinants related to context affecting conservation success include governance, cultural and societal values, and social/economic/public policies (Figure 1).

2.2 *Input Equity*

The socioeconomic and political context within a planning region gives rise to different forms of social position and hierarchy within groups of individuals. Populations can be stratified by socioeconomic position according to education, occupation, gender/age, race/ethnicity, generational, financial status and other factors (Figure 1). In some cases, these different groups participate in the conservation intervention through a participatory process, and help guide decisions about what and where to protect; we classify this as a form of input equity. For example, a decision process that includes only men or only wealthy people would be inequitable for those two types of input equity, and this may ultimately affect the ability to achieve the conservation outcome. In particular, the existence and equitability of the participatory process can directly influence conservation success by slowing or stopping the decision process, where in extreme cases the lack of a participatory process is responsible for failure of the intervention (Gleason *et al.* 2010). In other cases, the participatory process can influence the outcome of the intervention (e.g., the size or location or regulations of a protected area plan), which can in turn indirectly influence conservation success.

2.3 *Outcome Equity*

Outcome equity refers to the distribution of costs and benefits of the final outcome of the conservation intervention (e.g., a protected area plan) to different socio-economic groups and/or across space (Figure 1). For example, a protected area plan can disproportionately impact different socioeconomic groups, such as different industry sectors (Adams *et al.* 2010; occupation equity), by restricting access to a natural resource (access or spatial equity). In many cases input equity can influence outcome equity, as those involved in the decision process may design a conservation intervention that favors themselves and thus leads to outcome inequity, often for the same type of equity (e.g., if men dominate the decision process, they may produce outcomes that produce greater benefits for men). Outcome equity can be independent of input equity when conservation interventions do not involve a participatory process.

3 Equity and probability of conservation success

Once the types of equity relevant to a conservation intervention have been identified, conservation success requires understanding how these types of equity affect the probability of success. Increased social equity is often assumed to improve the probability of conservation success (Brown 2002; Halpern *et al.* 2013). In some cases, this assumption may be true; for example, in the implementation of locally managed marine areas, where self enforcement of new regulations is more likely to occur when local people perceive the regulations as equitable (Hatcher *et al.* 2000). However, it is also likely that conservation will fail if vocal or powerful individuals or groups are not satisfied with the outcome, in other words, if the outcomes of conservation planning and actions do not match the (often inequitable) local context. The relationship between equity and probability of conservation success is presumed to be positive (Brown 2002) yet is poorly understood, and further complicated when values and perceptions among and between different groups are taken into account too (Ravallion 2014; Figure 2). Recognizing the difference between absolute, relative and perceived is critical for objective setting and evaluation of intervention outcomes. Absolute equity refers to every participant experiencing the same, or equal, outcome. For example, regardless of size, every boat is allowed to catch the same number of fish (Figure 2). Relative equity refers to participants experiencing a proportional outcome related to a stated variable, e.g., boats receiving fish catch in proportion to their boat size as compared to other boats. Perceived equity is how those involved in the process perceive of their allotted outcome compared others, e.g., the size of fish catch relative to other fishers.

Here, we describe four general relationships that have been observed between equity and probability of conservation success (*P(x)*; Figure 3): A) Linear, where *P(x)* increases proportionally with increasing equity; B) Asymptotic, where *P(x)* increases rapidly with initial increases in equity and then plateaus; C) Humped, where *P(x)* rises initially and then drops off with higher levels of equity, and D) Sigmoidal, where *P(x)* responds slowly at first to increases in equity and then rises quickly. For nonlinear shapes, the location of inflection points (i.e., change in slope) is likely connected to a contextual determinant, such as governance or cultural value. For each relationship, we describe it in the terms of individual types of equity and support it using empirical evidence, where possible. These four relationships are hypotheses; their frequency of occurrence and impact on overall conservation outcomes are still to be fully tested. We hope the conceptual foundation described here helps make such testing more rigorous. For any equity type, its relationship with conservation success will likely vary from case to case depending on how equity is considered in the process (as an input or an outcome), how equity is measured (as quantitative or qualitative values, e.g., dollars versus participation effort), and how equity is defined (as absolute, relative or perceived) (McClanahan *et al.* 2008) (Figure 2).

3.1. *Linear*

Occupational and spatial equity are two of several types of equity that may relate linearly with conservation success (Figure 3a). For example, it seems reasonable to expect conservation plans that produce more equitable relative impact to each key occupational sector, would be more successful. In California, the Marine Life Protection Act Initiative is an example of a successful conservation plan that made considerable effort to equitably impact commercial fishery sectors in each major region (Klein *et al.* 2010; White *et al.* 2013).

With spatial equity, a linear relationship between equity and conservation success has been observed with a type of spatial fisheries management, Territorial User Rights in Fisheries (TURFs), which allow individuals or a set group of people to fish in a particular area. TURFs have demonstrated increasingly positive outcomes with increasing levels of both input and output equity. For example, Chilean TURF cooperatives allocate effort temporally and spatially via a pooling scheme (input equity), to equalize the work burden and spread effort in a more efficient manner (Cancino *et al.* 2007), and this program has successfully met conservation goals (by not exceeding the total allowable catch) and social goals (by equally distributing the transaction costs and benefits of the TURF) – an example of output equity.

3.2 *Asymptotic*

Financial and participation equity are two of several types of equity that could relate to conservation success asymptotically (Figure 3b), where conservation success increases with increasing levels of equity to a point, after which equity does not influence success. With financial equity, conservation success is assumed to increase with increasing financial equity (i.e., distribution between groups regardless of financial status or profitability). However, in some cases conservation success is likely to peak, and remain constant, when more powerful or vocal stakeholders receive the greatest benefit. For example, when the Great Barrier Reef was rezoned, the government provided monetary compensation to commercial fishermen but not to other, more profitable industries (Macintosh *et al.* 2010). As fishermen were the most vocal stakeholder group, allocation of additional money to other groups, an example of output equity, may not have impacted conservation success, resulting in an asymptotic relationship.

Similarly to financial equity, the probability of success of conservation interventions could increase, to a point, with increasing participation from stakeholder groups (participation equity). An example of how stakeholder participation can lead to successful conservation was demonstrated using data from 84 forest management cases around the world (Persha *et al.* 2011); whereas, lack of stakeholder participation lead to an unsuccessful conservation was shown in the first attempt to implement the California's Marine Life Protection Act (Gleason *et al.* 2010). Similarly, in Alaska where all federal fisheries are managed by annual catch limits and some type of limited access program, stakeholders and the public have several opportunities for participation input during the development phase, which is recognized as critical for building stakeholder acceptance of the program and balancing divergent interests (Fina 2011). However, this relationship is unlikely to be linear, as conservation success likely stabilizes once the most vocal or influential stakeholders are included in the process (i.e., engaging additional, less influential stakeholders in the decision process might increase equity but likely have little effect on conservation success).

3.3 *Humped*

Generational, gender, social, ethnicity, and financial (described above) are types of equity that could affect conservation success in a humped fashion, where the peak of the hump reflects the point in which conservation success is maximized. For example, some conservation initiatives favor current generations and disproportionately impose costs on future generations, indicating a humped shaped relationship that peaks early to reflect the bias towards current generations (Figure 3c) (Dobbs 1982). Generational equity would be difficult to achieve as a type of input equity given timeframes involved in most decision processes. In many societies, conservation success is generally assumed to increase linearly with increased gender equity inputs and outputs (Agarwal 2009; Figure 3a). However, conservation success probably peaks at a point that matches the power structure of a society. In many places, decisions are often made by, or favor, a single gender (Martin and Lemon 2001; Agarwal 2009; Tsikata and Golah 2010), thus conservation success would peak at the point that reflects this power structure. Other types of equity, in particular social class and ethnicity, often reflect different power and influence among groups within regions. In community forestry programs in Nepal, while socially dominant (higher caste) individuals make management decisions affecting all groups, lower caste social classes harvest a majority of the forest resources, and therefore conservation success is unlikely to occur until they are involved, even if at a minimal level. Yet, higher caste groups might not tolerate a substantial redistribution of decision-making rights among other social classes reflecting a humped relationship (Nightingale 2002).

3.4 *Sigmoidal*

Types of equity that potentially have an asymptotic relationship to conservation success would exhibit a sigmoidal relationship in cases where some minimum threshold level of equity exists that is needed to achieve success. For example, in fisheries management based on individual transferable quotas, each fisher (or fisher group) is allowed a ‘catch share’ (i.e., access equity) that can be used, sold, or leased. This form of regulation is only likely to be successful if some minimum threshold of output equity is achieved, or in other words, fishermen are not entirely excluded from the process. If access equity increases, more people are given access to a smaller portion of the fishery, assuming a total allowable catch has been set and remains constant, and thus individual catch would decrease. In this case, probability of success likely plateaus at some intermediate level of equity (sigmoidal relationship). For example, the halibut and sablefish fisheries have historically supported a large number of small vessels (Fina 2011). Both set individual fishing quotas (IQFs) to reflect historic fisheries access, but entry into the fishery is limited. Thus, probability of success increases to a point where enough of the fishers buy into the program, but probably plateaus at a point where entry (access equity) is limited and total allowable catch and catch shares remain steady.

3.5. Additional aspects of the curves

Some types of equity may express different relationship curves depending on the context. For example, with the catch allocation example in section 3.4, if individuals become less satisfied with their shrinking allocation of catch with increasing equity, they may begin violating regulations, in turn decreasing conservation success at higher levels of equity (humped shape curve instead of sigmoidal). Similarly, the relationship between financial equity and conservation success may be humped if groups without much power or voice receive money that could have gone to groups that feel they deserve more, causing those groups to perceive the allocation as inequitable and unacceptable for success.

A key unknown about any of the potential relationships between equity and conservation success is where the curve crosses an axis (Fig. 1a, inset). It is often assumed that conservation interventions will fail without some minimum level of equity (Borrini *et al.* 2004), such that the curves would intersect the x-axis at some value greater than zero. Yet there are other examples where conservation has been successful despite highly inequitable outcomes, for example where top-down management displaces local communities (Brockington 2004, de Santo *et al.* 2011). In these cases, the curves would intersect the y-axis at a value greater than zero.

Additionally, different types of equity, each with its own curve, may be relevant and important within the same management plan. Such differences further challenge incorporating equity into conservation planning, but can be resolved at least partially by efforts to elicit the relative importance of each type of equity to stakeholder groups and then incorporate those weights into formal multi-criteria decision making (Kittinger *et al.* 2014).

4 Discussion

We need a better understanding of the relationship between equity and conservation success, including when and how much social equity contributes to conservation success, to achieve conservation goals. We provide a conceptual foundation for understanding how and when different types of equity can influence conservation success relative to how equity is measured and perceived. Understanding the nature of these interactions between equity, conservation success, and economic return is fundamental for determining the feasibility of triple bottom line solutions. In conservation planning, expected conservation benefit is typically calculated as the product of probability of success and conservation benefit. In general, conservation benefit reflects both biodiversity conservation and economic efficiency objectives, addressing two pillars of the triple bottom line (Halpern *et al.* 2013). Here we demonstrate, in theory, how a third pillar, equity, potentially affects probability of conservation success (shown in Figure 3), and how this in turn interacts with the way equity can limit potential conservation benefits (Figure 4). The implication of these results is that equity can either exacerbate (Fig. 4b-d) or mitigate (Fig. 4a) the ability to achieve biodiversity and economic conservation objectives. In most cases, the optimal conservation outcome is achieved without perfect equity. In fact, high levels of equity could severely compromise conservation outcomes (e.g. Figure 4c) if, for example, existing power structures are themselves inequitable, which highlights the risk of not considering the relationship between equity and probability of success.

We simplified the problem by considering each type of equity separately, but acknowledge that complex relationships exist among specific types of equity and between context determinants (Adelman and Morris 1973), and that these interactions influence the degree of success. Further, we acknowledge that additional relationships are likely to exist (e.g., nonlinear shapes with multiple inflection points, flat lines where equity has no bearing on conservation success), and that the relationships may change through time, as people learn and adapt, and among communities that have different contexts. Similarly, different groups within a planning process may value different types of equity, and if those types influence the process (input equity) or respond differently to the conservation intervention (outcome equity), then overall conservation success could be compromised. A more indepth understanding of these relationships and interactions is important and will require empirical research focused on determining or evaluating specific relationships between the probability of success and equity, as well as how different types of equity are valued by stakeholders within a planning process (i.e., how much weight to give each one in planning decisions). Embarking on this substantial research agenda requires a conceptual foundation, which is the crux of this manuscript.

Complicating matters further, the actual relationship between equity and conservation success may differ from the perceived relationship of equity for different individuals or groups (Webb *et al.* 2004; McClanahan *et al.* 2008). Perceptions of equity and conservation success reflect the values of those involved in, or affected by, a program or strategy, their expectations, and whether goals are achieved (Axford *et al.* 2008). Perceptions are important as they lead people to change their behavior (*e.g.*, whether or not to comply to new regulations) and/or lead to new conservation actions (Claus *et al.* 2010). As with absolute equity, perceptions of equity will likely change through time and vary among individuals and communities, creating an additional challenge for understanding the relationship between equity and conservation success. Not all perceived values of conservation (associated with either costs or benefits) will be tangible or easily quantifiable; yet assessing their relative importance has merit. Any type of equity in principle could be measured subjectively on a unitless scale of low to high. Formalization of problems that involve values can be an anathema to some, but the benefits of explicating integrating these issues into formal conservation planning are greater than ignoring perceived values altogether.

Social equity in conservation has emerged from concern for environmental justice and fairness, in particularly, for those groups most affected by conservation interventions or most dependent on natural resources for their livelihoods. These issues reflect two important key ethical considerations. The first, which has been the primary focus of this paper, relates to how social equity among and between different groups might be represented in the process or outcomes of conservation planning. The second relates more specifically to how different types of equity are defined, by whom and for which groups. Goals reflect the values and beliefs of those individuals or groups that set them. We have suggested several key types of equity, but these are by no means exhaustive or prescriptive. Rather we provide a conceptual basis for articulating types of equity, the possible relationships between equity and conservation outcomes, and ways to interpret trade-offs among types of equity and between equity and conservation outcomes. Such a framework has the potential to inform and support rights-based approaches to conservation. It would be nearly impossible to consider all types of equity at once, thus conservation planners have to make some decision as to which types of equity to consider. Similar decisions are made when considering economic and ecological objectives, e.g., which actions to take to conserve which species (Bottrill *et al.*, 2008). How these decisions are made will depend on the local context in which the conservation intervention occurs, but we recommend an explicit conceptual framework to promote transparency and balance different perspectives.

Our conceptual foundation provides a lens through which issues of equity and conservation success can be viewed and studied using empirical data. This foundation informs further research required to resolve outstanding issues, including: 1) empirical evidence to document and measure the frequency of occurrence and effect of different types of social equity on the probability of conservation success; 2) information on whether minimum thresholds of equity are required to achieve conservation success (Figure 3a); 3) data on the contribution of equity versus other factors in affecting conservation success among different interventions, and potential tradeoffs among these factors; 4) a systematic review to synthesize existing evidence on which types of interventions, and their relative conservation success, are most influenced by which types of social equity; and 5) definitions and perceptions of conservation success among and across different groups and contexts. Greater knowledge of these issues will improve our understanding of how and when to consider equity in conservation decisions making.

Multiple objectives are common in conservation, yet there is not always consensus on objectives among individuals and groups. Conservation planning can only strive to achieve the stated objectives and ensure that the objectives are clear, measurable and identified through a transparent and participatory process with multiple stakeholders. Governments and organizations are increasingly moving away from purely biophysical approaches to biodiversity conservation to more holistic approaches based on sustainable human interactions, which require integration of environmental, social, and economic demands. Although substantial work has been done to promote the need for addressing social factors in effective planning design and implementation (Ban *et al.* 2013), there has been little focus on social equity and its influence on conservation outcomes, despite the assumption that triple bottom line solutions are commonly held as ideal. We hope our work here will help improve conservation success by shedding light on how and why equity influences the probability of success, the consequences of not adequately considering equity on conservation outcomes, and provide guidance on tradeoffs among social equity, economic efficiency, and conservation effectiveness for conservation interventions.

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Figures

Figure 1.

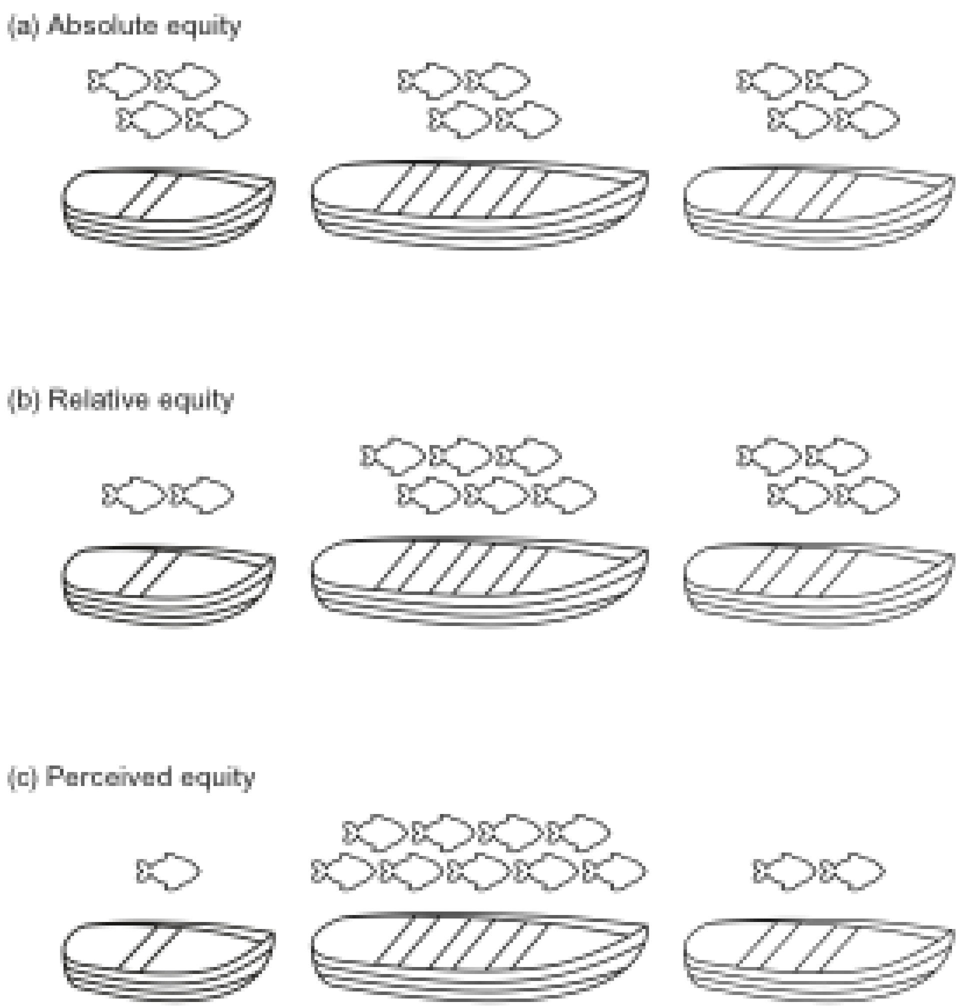


Figure 2

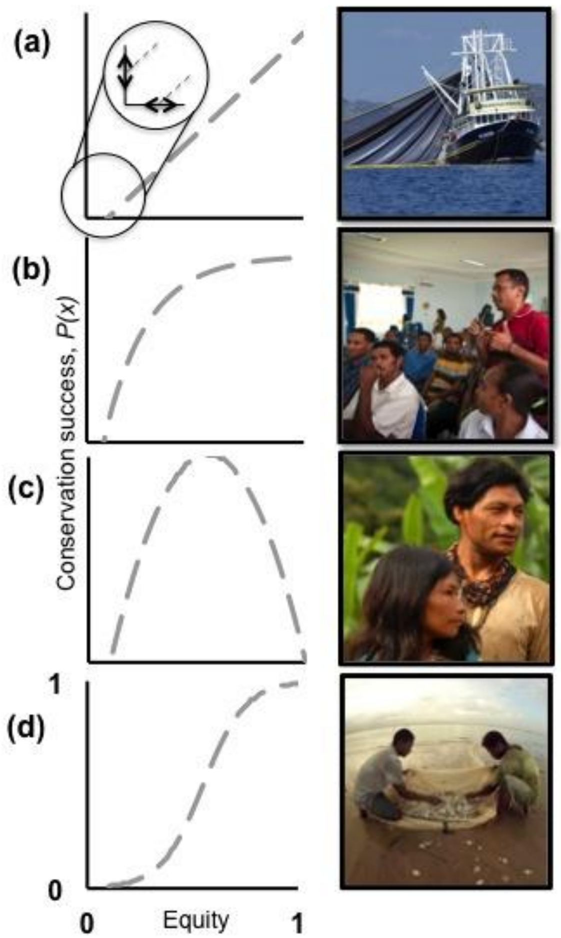
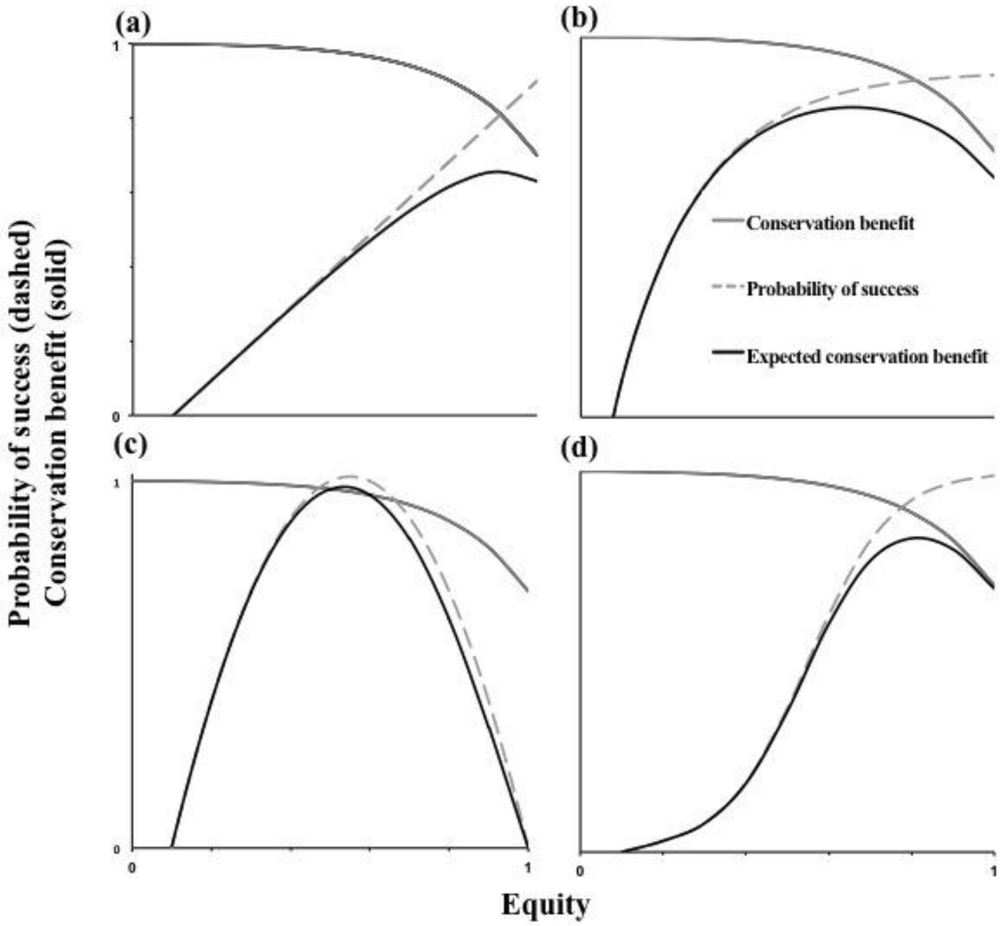


Figure 3



(a)
(b)
(c)
(d)
Probability of success (dashed)
Conservation benefit (solid)
Conservation benefit
Probability of success
Expected conservation benefit
1
0
1
0
1
0
0
1
0
1
Equity

Figure 4

Figure Legends

Figure 1. (a) Conservation success can be influenced by several different types of equity (described in b), both as an input into (e.g., participation by stakeholder groups) and/or an outcome of the conservation intervention (e.g., access to natural resources by individuals or groups). Each type of equity can be influenced by a variety of socioeconomic and political context determinants.

Figure 2. Equity influences conservation success in different ways, depending on how it is measured and perceived. Potential measures and perceptions are illustrated for access equity, where a management plan limits fishing access to different fisher groups (each with a different size boat). When measured in absolute terms (a), each group benefits equally, represented by catching the same number of fish; when measured in relative terms (b), the benefit is distributed proportionally to the size of the boat. (c) the group with the largest boat has a positive perception of the relative benefits, whereas groups with smaller boats have a negative perception.

Figure 3. Four broad classes of relationship between equity and the probability of conservation success, $P(x)$: (a) Linear; (b) Asymptotic; (c) Humped; and (d) Sigmoidal. A value of 1 indicates perfect equity and conservation success. For each relationship, we do not know where they cross an axis (shown in (a)). If there is a minimum threshold of equity, below which there is zero chance of success, then the lines would cross the x-axis; whereas if success is possible in

inequitable situations, the lines would intercept the y-axis. Photos represent equity types that can exhibit the associated relationship, occupational, participation, gender, and access, respectively.

Photos courtesy of (a) Urlich Karlowski; (b) World Wildlife Fund, Inc. Tory Read; (c) Trond Larsen; (d) Cristina Mittermeier.

Figure 4. The relationship between equity and conservation benefit (i.e., success), and how different relationships between probability of success (P(x), from Fig. 3), given different levels of equity modifies the ability of the conservation intervention to achieve biodiversity conservation outcomes. The solid gray line shows a general possible trade-off between conservation benefit and equity (taken from Halpern et al. 2013). The dashed gray lines show four possible relationships between equity and probability of success, described in Figure 3. The solid black lines are the resulting consequence of these probability relationships on the degree to which conservation success is achieved (expected conservation benefit).

Figure 1a
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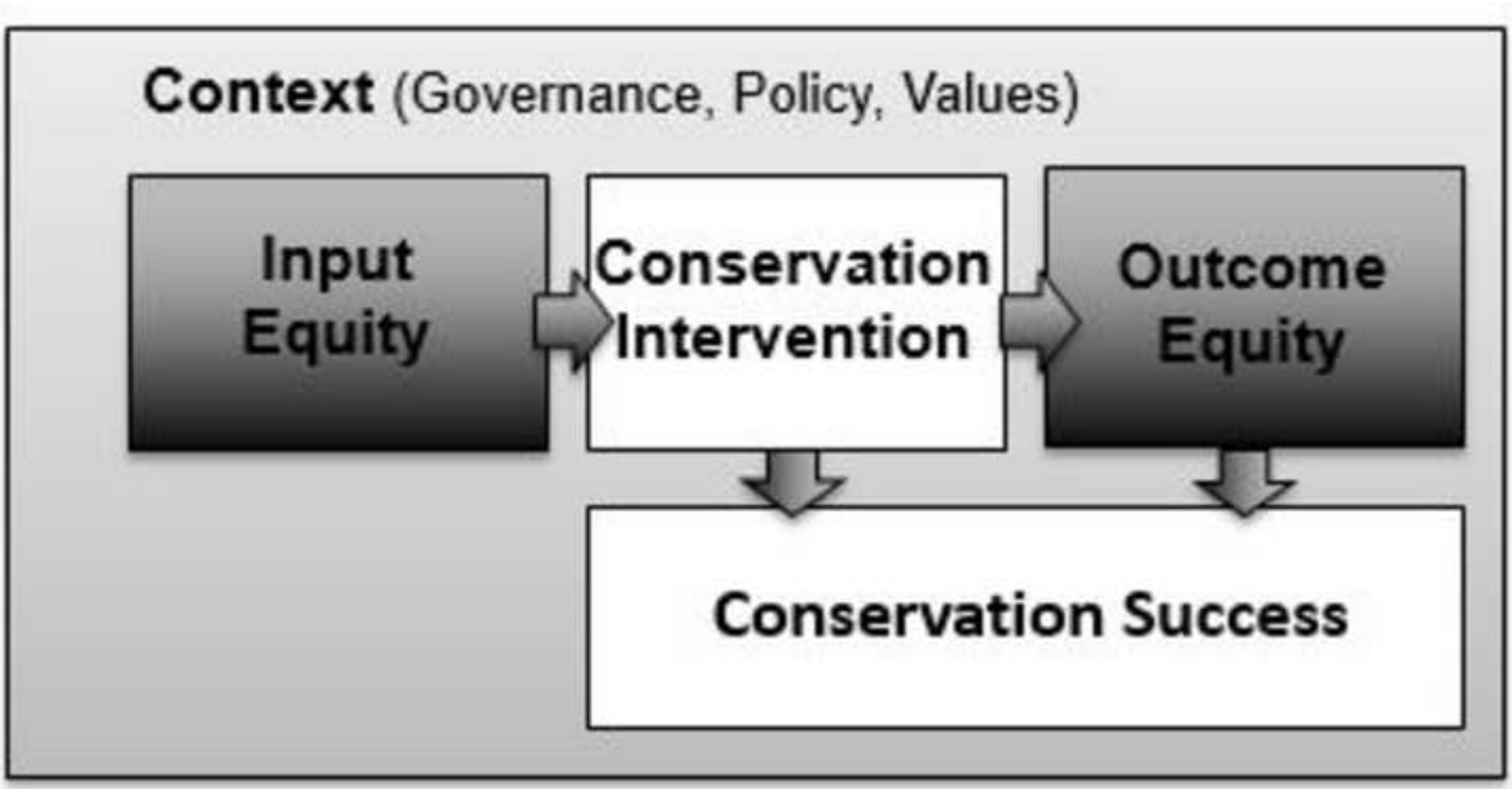

Figure 1b

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Equity Type	Description
Social class	Distribution of benefits or costs to each class, or people, according to set of hierarchical social categories
Gender	Distribution of benefits or costs to each gender group, where 50:50 ratio is perfect equity
Ethnicity	Distribution of benefits or costs to individuals or groups by cultural or indigenous status
Generational	Distribution of costs or benefits to each generation
Educational	Distribution of benefits or costs based upon level of education attainment (e.g., primary, secondary, tertiary)
Occupation	Distribution of benefits or costs to each occupational sector, where a sector could be individual types of fisheries (e.g., crab, tuna), different fishery groups (e.g., commercial, recreational), or different industries (e.g., wind farming, tourism)

Figure 1c
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Equity Metric		Description
Participation	I	Representation by type of stakeholder group in participatory conservation process of decision
Access	O	Amount of non-spatial access allocated to individuals or groups, such as access (or no access) to natural resources during a particular time period or season.
Spatial	O	Amount of space or area on the landscape/seascape allocated to individuals or groups
Financial	O	Amount of income or profitability allocated to individuals or groups

Figure 2
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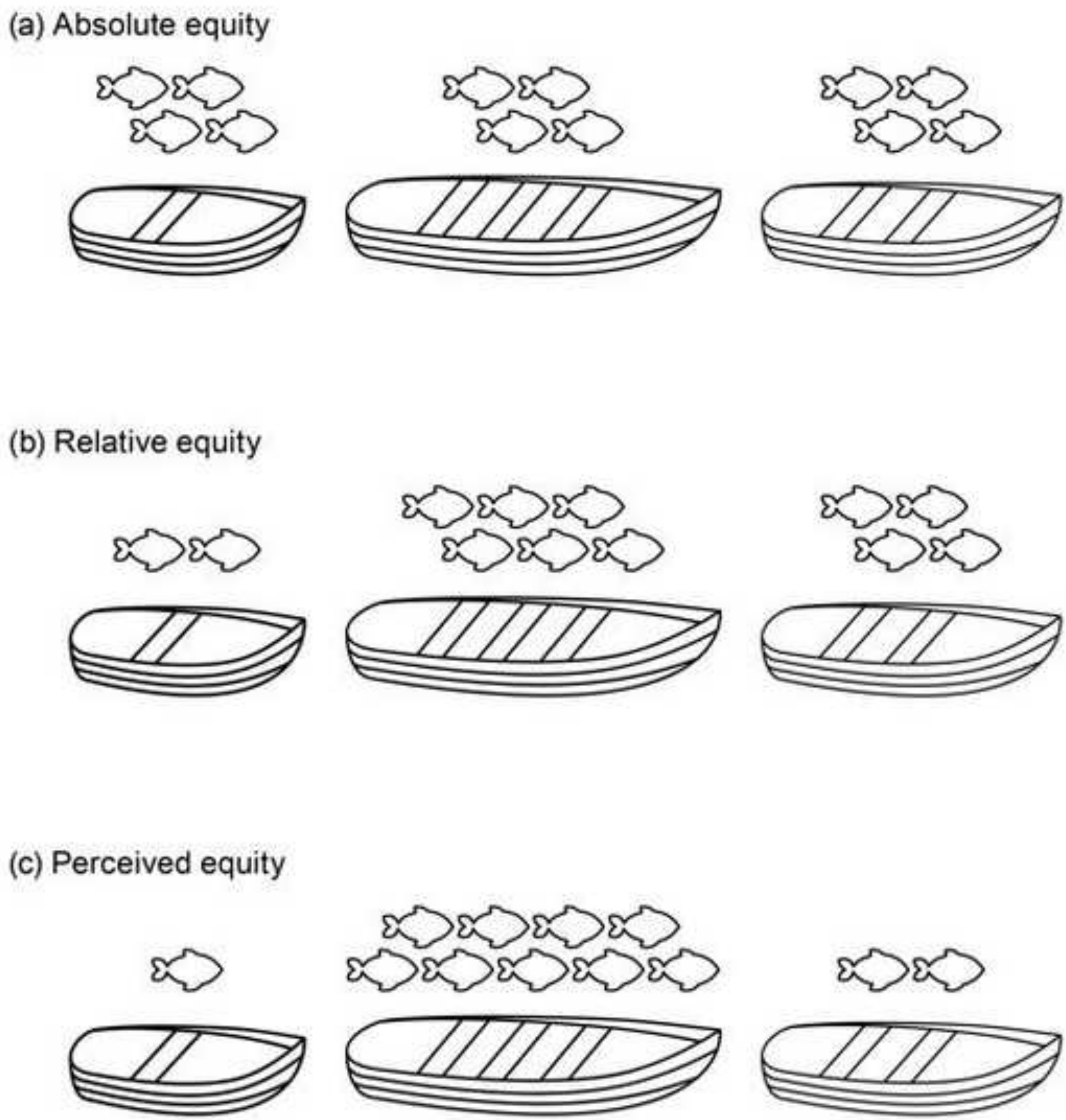

Figure 3
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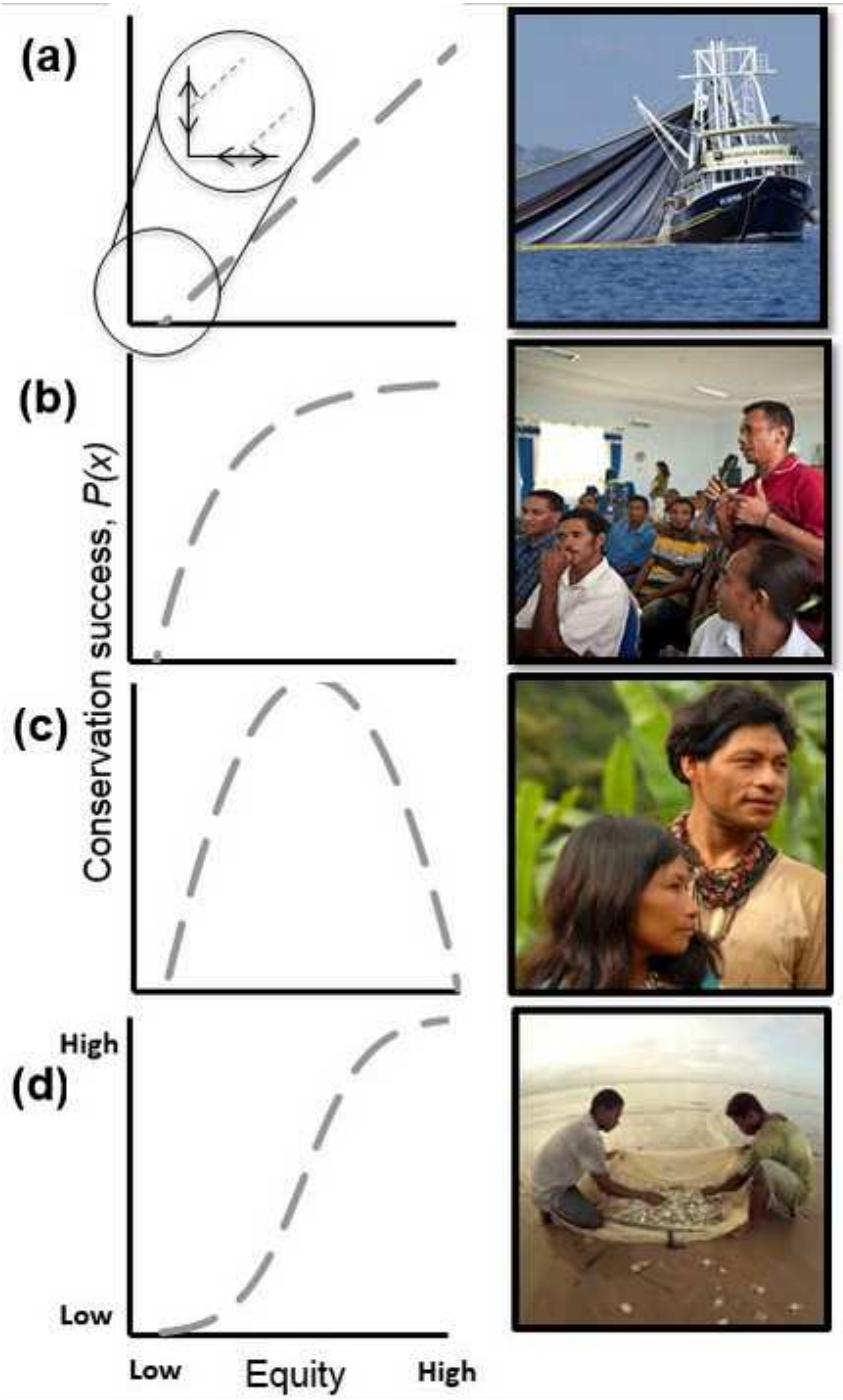

Figure 4
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