Title: Traps and sustainable development in rural areas: A review

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Abstract

The concept of a poverty trap – commonly understood as a self-reinforcing situation beneath an asset threshold – has been very influential in describing the persistence of poverty and the relationship between poverty and sustainability. Although traps, and the dynamics that lead to traps, are defined and used differently in different disciplines, the concept of a poverty trap has been most powerfully shaped by work in development economics. This perspective is often constraining because, as many studies show, poverty arises from complex interactions between social and environmental factors that are rarely considered in development economics. A more integrated understanding of poverty traps can help to understand the interrelations between persistent poverty and key social and ecological factors, facilitating more effective development interventions. The aim of this paper is to provide a critical appraisal of existing trap conceptualizations in different disciplines, and to assess the characteristics and mechanisms that are used to explain poverty traps in rural contexts, thereby broadening the traps concept to better account for social-ecological interactions. Complementarities and tensions among different disciplinary perspectives on traps are identified, and our results demonstrate that different definitions of traps share a set of common characteristics: persistent, undesirable and self-reinforcing. Yet these minimum conditions are not sufficient to understand how trap dynamics arise from complex social-ecological interactions. To broaden the utility of the concept we propose a more social-ecologically integrated definition of traps that includes four additional considerations: cross-scale interactions,

path-dependencies, the role of external drivers, and social-ecological diversity.

Including these wider dimensions of trap dynamics would help to better account for the diverse social-ecological feedbacks that produce and maintain poverty traps, and could strengthen strategies to alleviate poverty in a more integrated way.

Keywords: traps, poverty, social-ecological, development

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1. INTRODUCTION

Poverty remains one of the most important global challenges facing humanity. Ending 'poverty in all its forms everywhere' (United Nations, 2015) while at the same time not increasing pressure on ecological resources and processes (Steffen et al., 2015; Raworth, 2017) is a long-standing challenge, most recently rearticulated as the first United Nations Sustainable Development Goal. Poverty is caused by complex interactions between social and environmental factors (Nunan, 2015); therefore, integrated conceptualizations of poverty are required to meet this challenge. A synthetic understanding of poverty traps can help to better understand the interrelations between persistent poverty and environmental sustainability.

Conceptualizations of persistent – versus transient – poverty (Ravallion & Jalan, 1998; Hulme, 2003), and the resulting alleviation strategies, often rely on the concept of poverty traps (Azardiadis & Atachurski, 2004; Bowles, Durlauf & Hoff, 2006; Barrett & Swallow, 2006; Carter & Barrett, 2006; Barrett & Carter, 2013). The concept originates in development economics, where it is commonly used to describe and explain persistent poverty under a certain threshold, either with one (Cao, 2009; Glauben et al., 2012) or multiple, equilibria (Barrett & Swallow, 2006). In this literature, a poverty trap is characterized by self-reinforcing mechanisms that maintain poverty by keeping people or communities below a certain asset threshold.

The implication of this conceptualization is that escaping a poverty trap requires crossing asset thresholds. When certain asset thresholds are not reached due to

lack of opportunities (e.g. access to markets) or capacities (e.g. access to knowledge or capital), a big push in the form of asset inputs is often advocated to move across this threshold (Barrett & Swallow, 2005). The idea of a 'big push' has become a common poverty alleviation strategy, and when coordinated in a multi-faced way, is evidenced to be effective (Enfors, 2012; Banerjee et al., 2015). Other studies suggest however, that 'big push' strategies can also perpetuate poverty (Green & Hulme, 2005; Easterly, 2006).

Further, the concept of poverty traps neglects important insights from many years of research on poverty. This includes the intergenerational, cultural and institutional barriers to poverty alleviation (Bowles et al. 2008); the role of inequality in perpetuating poverty (Green & Hulme, 2005; Bétrisey et al. 2016); and fundamentally that poverty is itself, and is experienced as, multi-dimensional, which means that along with lack of income, poverty can include other factors such as exposure to violence or poor health (Sen, 1999; OPHI, 2010). Furthermore, cross-scale interactions between multiple low-level equilibria (Barrett & Swallow, 2006) or between social and ecological factors (Maru et al. 2012) are generally not considered in studies on traps thus far (Barrett & Constanas, 2014).

Poverty traps have however recently received increasing attention beyond development economics. Trap dynamics for instance are frequently analyzed in sustainability research (Gunderson & Holling, 2002; Allison & Hobbs 2006; Carpenter & Brock, 2008; Maru et al. 2012; Barrett & Constanas, 2014; Laborde et al. 2016, Cumming 2017), where they are considered an emergent outcome of

complex social-ecological interactions. A recent special issue on social-ecological traps highlights various new ways of conceptualizing trap dynamics in natural resource management (Boonstra et al. 2016; Enqvist et al. 2016; Tidball et al. 2016). Considerable ambiguity remains around how trap dynamics are conceptualized, interpreted and used in sustainability science and beyond. The widespread use of the traps concept across different research fields, often with different meanings and understandings, has led to fragmented understanding.

The overall aim of our paper is to broaden the concept of poverty traps to incorporate key social and ecological factors that can be critical for addressing situations of persistent poverty in rural contexts. We focus on trap dynamics explicitly, rather than on chronic poverty more generally, because the traps concept has been particularly influential and pervasive in many different disciplines, and is often specifically used to link poverty and sustainability challenges (Maru et al. 2012; Barrett & Constanas, 2014; Brown, 2016). Moreover, our focus is on traps at the local level, specifically in rural communities, not the national or international levels, since the local level is the focal scale of most literature on sustainable development in rural contexts.

To address the overall aim, we focus on three specific objectives that are addressed with two linked literature reviews and a synthesis. First, we conduct a literature review of how trap dynamics are conceptualized across a broad range of disciplines to identify opportunities for broadening the concept of poverty traps beyond economic development and asset levels (objective 1). Second, we carry out a more in-depth review of the literature of traps in rural contexts to

better understand social and ecological drivers and mechanisms of trap dynamics (objective 2). The second review focuses on papers that specifically analyzed trap dynamics in local rural contexts located (predominantly) in the Global South, where over seventy percent of global poverty is situated (Olinto et al., 2013).

Finally, we integrate insights from these two complementary reviews and the social-ecological literature to synthesize key aspects of trap dynamics that can help underpin a more holistic approach to understanding and applying the concept of poverty traps in both research and development practice (objective 3).

2. METHODOLOGY

This paper extends the scope of existing reviews of poverty traps (e.g. Bowles et al., 2006; Maru et al. 2012; Tidball et al. 2016) in two ways. First, we review a very broad range of literature from psychology to sociology to sustainability science to uncover different conceptualization of trap dynamics, and second, for the first time, we provide a systematic overview of characteristics and mechanisms of traps in rural contexts.

Both the broad and in-depth reviews are structured using a Social-Ecological Systems (SES) framework, which assumes that social and ecological dynamics interact as a complex adaptive system (Folke et al., 2010; Levin et al., 2013). This framing focuses on: a) the interdependence of social and ecological factors (Folke et al. 2016); b) interactions across multiple spatial and temporal scales

(Gunderson and Holling, 2002); and c) how multiple local interactions and adaptations over time give rise to traps (Levin et al. 2013).

2.1 Step 1 - Review of trap dynamics across research fields

A literature search using the Institute for Scientific Information (ISI) Web of Knowledge was conducted between January 2013 and November 2015 to capture publications that cover trap dynamics in relation to the persistence of poverty and its interrelation with environmental sustainability. The Web of Knowledge was used because of its broad range of papers across disciplines, large temporal records, and selection of scientific articles appearing in reputable journals (Arezoo et al., 2013; Chadegani et al., 2013). The search term used was: TS = (poverty trap OR rigidity trap OR cognitive trap OR lock-in OR social trap OR chronic poverty) AND TS = ((sustain* OR resilienc* OR environment*) OR (develop* OR social*)), resulting in 6,267 papers (Web of Knowledge Core Collection). The search term was selected to represent a broad spectrum of trap dynamics (i.e. including lock-in, persistence), and to limit papers to sustainability and development related problems. Only English language and peer review papers were considered. Given the focus of our study we limited our search further to Web of Knowledge Research Areas (RA) that are relevant for sustainability related problems. These were business economics, public administration, environmental sciences, ecology, biodiversity conservation, agriculture, fisheries, forestry, history, geography, anthropology, social sciences, psychology, sociology, social sciences, social work. Publications that mentioned traps in the context of physical traps (i.e. animal or insect traps) were excluded,

as were any publications clearly beyond the scope of our study (e.g. traps mentioned in medical journals).

This refined search produced 2,345 papers, which we grouped into seven research fields to facilitate comparing representative conceptualizations across different disciplines. These research fields were labeled by the authors as: Development Economics, Rural Development, Environmental Science, Sociology, Psychology and Social-Ecological. Development economics for example combined papers from ISI research areas business economics and public administration; Environmental Science from ISI research areas ecology, biodiversity, environmental sciences, conservation, agriculture, fisheries, and forestry. The rural development category captured papers from business and economics, as well as public administration which included the term 'chronic poverty.' The social-ecological category was created to represent papers that explicitly considered dynamics of social-ecological relationships and that did not fit into any of the other categories because they combined otherwise divergent research areas.

Two of the most highly cited papers in each category were selected for further analysis. All of the selected papers have been cited more than 50 times, indicative that they are important for their respective research field. In cases where the highest cited papers were not relevant for sustainability science, the next most cited paper was selected. Each of the selected papers was scored with respect to the defining features of the trap dynamics, how they were measured, and typical interventions proposed for overcoming traps (see Table 1, Results).

2.2 Step 2 - Review of trap dynamics in rural contexts

Web of Knowledge was used to select papers for the second review. The search term: TS=(("poverty trap*") OR ("rigidity trap*") OR ("cognitive trap*") OR ("dependency trap*") OR ("lock-in*") OR ("social trap*") OR ("persistent poverty*")) AND TS=(("pastoral*" OR "agricultur*" OR "rural*" OR "fish *")) was used to identify research papers that specifically addressed trap dynamics in rural contexts. The search returned 269 papers. The abstracts and titles of the papers were screened to ensure that they address traps in rural contexts. Papers were only included in the review if they included either primary data or theoretical models, as both reveal insights on the causal mechanisms of traps. Reviews were therefore not included in this in-depth review, but were included in our qualitative assessment of social-ecological literature in Supplementary Material C.

To ensure a diverse set of papers was represented, the final set of papers analyzed were selected by applying three principles of diversity (Stirling, 2010): balance (all relevant scientific disciplines identified in step 1 represented), variety (sufficient number of different types of traps and contexts), and disparity (ensuring there was a certain degree of difference in the approaches, contexts and types of traps identified in the studies). This ensured that papers were balanced for geographical variety (to ensure cases from South and Latin America, Africa and Asia), data type (the majority of papers draw on panel data, so a number of papers with more qualitative methods were selected), and representation of both empirical and theoretical content. Papers that mentioned

traps (or other related keywords) in the title and/or abstract, but provided no analysis on the mechanisms that create or maintain traps were excluded. In total, 30 papers were subjected to in-depth review (Supplementary Material A).

To consistently code the papers, the first author read and coded all the papers with other co-authors periodically coding randomly selected papers and comparing these results to address any inconsistencies in the coding process. When inconsistencies occurred, they were discussed amongst the author team and coding for all papers in the set was adjusted accordingly to ensure consistency.

The coding and subsequent analysis of the selected papers was guided by the social-ecological framework in order to analyze how the studies address interdependence between social and ecological variables, interactions across scales and the characteristics of complex adaptive systems (Folke, 2010). In the first round of coding, the name of the trap, the definition, the integration of social and ecological dynamics, the type of study, the research area, the scale of analysis and the normative assessment of the trap were coded. Second, the papers were further compared with respect to drivers, mechanisms and alleviation strategies developed by the studies (variables are defined in detail in Supplementary Material B).

The papers from this second, in-depth, review were grouped into two meta-categories, 'development economics' and 'environmental conservation' based on their research area and category in Web of Knowledge (e.g. business and economics vs. biodiversity and conservation, respectively) in order to identify

key differences between trap dynamics as described by development economics and fields associated with or closely related to sustainability.

3. RESULTS

3.1 Conceptualization of traps across research fields

Scientific articles on traps across different research fields are published with increasing frequency. In 2000, there were 137 publications, while in 2015 this number grew to 655, a four-fold increase. More than 50 percent of these papers fall into the meta-category of ‘development economics’ (1,207 of 2,345).

Three of the research fields (development economics, rural development and social-ecological) focus on poverty, while the remaining fields investigate other types of persistent undesirable states such as lock-ins (environmental science), social traps (psychology) or path-dependent processes (sociology). As described above, development economics conceptualizes a poverty trap as a persistent, self-reinforcing state under a well-being threshold that needs to be overcome through increased inputs or institutional changes. Rural development and the social-ecological literature conceptualize trap dynamics related to poverty differently. A typology of ‘trap’ conceptualizations and summary of the key distinguishing features across the different fields is shown in Table 1.

Table 1. Typology of conceptualizations of traps across disciplines

Research fields	Common types	Main defining features	Measurement	Typical interventions	Representative Papers
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Development economics	Poverty trap	Poverty persists under a certain threshold, at multiple stable state(s)	Well-being (household income)	Increased inputs, institutional reconfiguration	Carter & Barrett (2006), Lybbert et al. (2004)
Rural Development	Chronic Poverty	Poverty is multi-faceted; non-homogenous group; intergenerational poverty	Emphasizes the social relationships and constructs which reproduce poverty	Contextually variable: re-distribute assets, reduce social exclusion, long-term social security	Hulme & Shepherd (2003), Cleaver (2005)
Social Ecological	Poverty traps, rigidity traps, lock-in traps	Maladaptive, Low potential (to change), low connectedness and low resilience; multiple equilibria	Reinforcing social and ecological feedbacks	Create/enhance alternative feedbacks.	Allison & Hobbs (2004), Carpenter & Brock (2008)
Environmental sciences	Lock-in	Increasing returns to scale	Persistent market and technology failures	Exogenous interventions; Change in incentive structures	Unruh (2000), Wilson & Tisdell (2001)
Sociology	Path dependence	Traps are trajectories, not equilibria, dependent on critical junctures	Mechanisms that create self-reinforcing processes; reactive sequences.	Influence the causal mechanism (intervening variable)	Mahoney (2000), Pierson (2000).
Psychology	Social trap	Mismatch between short term stimulus and long-term effect	Reinforcement becomes negative over time	Modifying reinforcement	Platt (1973);

In the rural development literature ‘chronic poverty’ is used as a concept to describe the persistence of poverty over time, often over generations. It goes beyond a narrow focus on income or consumption by highlighting the multi-

dimensional and heterogeneous nature of poverty, and accounts for the social relationships and constructs, such as institutions, that cause poverty to be transmitted across generations (Cleaver, 2005; Green & Hulme, 2005). Among causes of poverty, the rural development literature highlights unequal access to, and control over, resources and discusses institutional change as a strategy to addresses structural inequity (Green & Hulme, 2005).

Poverty traps in the social-ecological literature are conceptualized as unsustainable or undesirable situations that are reinforced through feedbacks between social and ecological processes. The focus on reinforcing feedbacks is similar to the development economics conceptualization; however, these studies focus on the feedbacks between social and ecological processes, such as agricultural activities and their impact on soil (Enfors, 2012). Conceptualizations of trap dynamics often use the ecological concept of resilience and emphasize that maladaptive states exist and interact across different spatial and temporal scales (Gunderson & Holling, 2002). From this viewpoint, escaping a trap requires creating new feedbacks, strengthening desirable feedbacks, and breaking undesirable ones.

In addition to poverty traps, the social-ecological literature identifies two other types of traps: rigidity and gilded traps. Rigidity traps are situations in which components of the system become overly connected, self-reinforcing and inflexible to the point that social-ecological systems become vulnerable to shocks (Gunderson & Holling, 2002; Scheffer & Westley, 2007). A social-ecological example of rigidity traps is the managed forests in eastern Canada, which are

chronically infested with tree-killing defoliating insects in which the persistence of industrial forestry required continual and substantial investment in insecticide spraying (Gunderson & Holling, 2002). Gilded traps are situations in which a certain activity, such as the extraction of a resource, is maximized for efficiency or profit at the expense of diversity, which increases the vulnerability of the social-ecological system (Steneck et al., 2011). The social-ecological literature suggests interventions that break dominant reinforcing feedbacks that maintain the trap in order to break trap dynamics (e.g. Enfors, 2012). An extended review of the social-ecological literature is found in Supplementary Material C.

Lock-ins, as described by environmental science and some of the social-ecological traps research, often refer to technical systems and concern situations in which a society gets stuck with a particular technology that once established is very difficult to change. Classic examples of technological lock-in are the dominance of pesticides in agricultural systems (Cowan & Gunby, 1996), the carbon lock-in where industrial countries have become locked-in to fossil fuel energy systems and the use of gasoline engines (Featherstone et al. 2005); these examples are quite similar to the rigidity trap described by the social-ecological literature. Lock-ins are perceived to be the consequences of increasing returns to scale in the initial phase of the spread of a new technology, which then co-evolves with society and institutions (Unruh, 2000). Lock-ins in this literature can only be overcome through exogenous forces, such as large-scale policy or societal change, or through niche technology development (such as small-scale

solar development in the case of carbon lock-in) to break the lock-in dynamics (Unruh, 2002).

Path dependency is the main defining feature of sociological conceptualizations of trap dynamics. Social change processes, which can be conceptualized as pathways over time, can exhibit critical junctures beyond which they are confined to following a particular path (Mahoney, 2000). The temporal dimension differentiates path-dependency from conceptualizations that focus on alternative equilibria separated by a threshold, as is common in economics and most of the social-ecological literature. Boonstra & de Boer (2013) have outlined how path-dependency can be used for the analysis of social-ecological traps. Interventions to avoid and move out of traps thus try to identify how critical junctures could be influenced to change the chosen pathway and thereby prevent emergence of trap dynamics (Boonstra & de Boer, 2013).

In psychology, trap dynamics are studied at the level of individuals to understand how people get trapped in unhealthy or unsustainable behaviors. Traps are conceptualized here as mismatches between short-term stimuli and long-term effects (Platt, 1973). Studies explain, for instance, the persistence of smoking as a mismatch of the short-term enjoyment of a cigarette and the longer-term health consequences. Temporal and scale mismatches also underlie social dilemmas of collective action, such as the tragedy of the commons where a group of people overharvests a shared resource. Here the positive self-reinforcing short-term stimulus to exploit the resource at the individually optimal level conflicts with collective benefits and long-term sustainable use

(Rothstein, 2005). The psychological literature suggests that the short-term stimulus should be reduced or removed in order to avoid persistent negative individual behavior, (i.e. the trap).

Some of the traps conceptualizations represented in Table 1 may be mutually exclusive (e.g. the exogenous interventions advocated by development economics and environmental sciences do not match the more endogenously empowering intervention strategies proposed by the rural development literature). However, some other features from disparate research fields may be synthesized. The seeming incommensurability of multiple-equilibria versus path-dependency approaches for example can be reconciled through their common approach of identifying a poor initial condition. The opportunities and challenges for synthesis are addressed in sections 4.2 and 4.3.

3.2 Understanding trap dynamics in rural contexts

The second review provides an in-depth look at characteristics and mechanisms of trap dynamics in rural contexts.

3.2.1 Types of studies and traps in rural contexts

Figure 1. Types of studies, definitions of traps and social-ecological integration in rural contexts

The majority of conceptualizations of trap dynamics in this set of publications are poverty traps, but other types of traps are also used (Figure 1, *trap name*). There is general agreement of what *defines* a trap (Figure 1) across the studies: a trap can be defined as a persistent, undesirable state with reinforcing internal dynamics inhibiting an individual/household/system to surpass a given asset threshold. For synthesis purposes, asset in most cases simply means a useful or valuable good, acknowledging that within studies of trap dynamics there has been much discussion about asset-based approaches vs. solely income-based

measurements of poverty (Carter & Barrett, 2006). The studies that do not refer to a minimum asset threshold are generally publications that deal with a different type of trap, or lock-in that was unrelated to poverty, such as a technological lock-in (e.g. Vanloqueren & Baret, 2009).

Our results demonstrate that very few development economics studies (15 percent) explicitly assess social-ecological feedbacks, while 80 percent of the environmental conservation studies take social-ecological interactions into consideration. Admittedly, some development economics papers, such as Carter et al. (2007), assess the role of environmental variables in causing poverty to persist, but without considering their feedback effects. Some more recent studies, (e.g. Barrett and Bevis, 2015) take social-ecological feedbacks into more explicit consideration.

Most studies analyzed traps at the household level (Figure 1, *scale of analysis*). Eighty-eight percent of these were development economics studies, which commonly analyze income trends over time to identify the existence of a trap. Two of these studies also investigate trap dynamics, or its causes, at or across local/community levels (Barrett 2008, McPeak & Barrett 2001). McPeak and Barrett (2001), for example, analyze how community-level variables, such as rainfall, influence individual responses at the household level. Environmental conservation studies are more likely to identify the trap at local or regional levels (nine out of 12 cases). Some of these studies also address cross-scale dynamics, for example Coomes et al. (2011) describe the relationship between household level poverty and community level land-use planning. However, overall only four

of the 30 studies explicitly consider cross-scale dynamics (Cowan & Gunby, 1996; Coomes et al., 2011; Barrett & Swallow, 2006; Steneck, 2011). None of the studies reviewed addressed poverty traps at the national-level.

All studies consider traps to have negative consequences (Figure 1, *normative assessment of traps*) but some consider tradeoffs between positive and negative consequences (43%). For example, Steneck et al. (2011) describe the gilded trap as an ‘undesirable’ situation overall, but which provides significant benefits to some actors at the expense of others.

3.2.2 Characteristics and mechanisms of traps in rural development contexts

More than 50 percent of the studies describe the dynamics of traps as having multiple equilibria (Figure 2, *trap dynamics*). The dynamics are classified as trajectory (six cases) if the temporal dynamics of the trap are explicitly mentioned, for example as a continuously deteriorating condition that reinforces the trap (Swallow et al., 2009), or if path dependency is explicitly recognized (such as in Vanloqueren & Baret, 2009, and Rudel, 2013). A ‘fixed’ point trap was identified as any study which addresses a static trap at one scale. An example of a ‘fixed’ point trap is represented in Naschold (2012), who shows how structural immobility across societal classes is pervasive and multiple alternative equilibria are not revealed by the panel data from their study in semi-arid rural India.

Figure 2. Characteristics, drivers, mechanisms of traps in rural contexts and strategies to escape them

Despite the fact that the environmental conservation studies often invoke the importance of understanding the resilience of a social-ecological system to shocks (Folke, 2010), only 40 percent of these studies identify shocks as a causal driver. The results indicate that development economics studies are more likely to attribute trap dynamics to a shock (60 percent, Figure 2, *shock as causal driver*). In most cases these shocks are environmental, e.g. drought in pastoral systems (Lybbert et al., 2004), or include other natural disasters such as

hurricanes (Carter et al., 2007), which push households into a low welfare state from which they cannot recover.

Persistence is the key-defining feature of traps (see Figure 1, *trap definition*). The most common measure of persistence is the time spent in an undesirable state (e.g. measured by panel data over more than five years) (Figure 2, *persistence*). In most instances this measure was complemented with information about the return time to a more desirable state (generally in the context of responding to shock), as the two are logically correlated. It is questionable whether the time spent in an undesirable state itself is sufficient to indicate the existence of a trap. Measures that indicate strong causality for the existence of a trap, such as the persistence of poverty despite interventions, is demonstrated in 30 percent of the studies.

Drivers are defined rather broadly as any precipitating factor or condition that generates traps (Figure 2, *drivers*). Initial condition is thus grouped under drivers because it has been identified as a causal factor of traps. Across the studies, there lacks consensus on key drivers. The most common factor triggering trap dynamics is poor initial condition (16 studies). Fourteen of these 16 studies are from development studies, where poor initial condition supports the commonly held narrative that ‘the poor stay poor’ (Naschold, 2012).

Examples of poor initial condition include: small land holdings and low caste (Naschold, 2012), initial herd size (Lybbert et al., 2004), inability to respond to shocks or drought (Carter et al., 2012), and remoteness (Barrett et al., 2006).

Only two of the environmental conservation studies identified poor initial

condition as a causal factor of traps; both are cases where there were historical legacy effects (e.g. small initial landholding) disenfranchising a marginalized population (Coomes et al., 2011; Rudel, 2013). The most common driver identified by environmental conservation studies was economic or political change (e.g. Allison & Hobbs 2004; Cinner et al., 2009; Swallow et al. 2009; Steneck et al. 2011; Rudel et al., 2013). The role of drivers external to the scale of analysis of the system is a point we return to in the discussion.

More than two thirds of studies across development economics and environmental conservation studies identify self-reinforcing feedbacks as the major *mechanism* of traps (Figure 2). As stated before, the main difference between development economics and the environmental conservation studies is the focus on economic versus social-ecological feedbacks, respectively. The second most prominent mechanism, lack of natural capital, is also mentioned as a critical factor perpetuating poverty traps in half of the studies. However, in most cases natural capital is seen as an input to the primary production processes, and not as an interdependent part of a social-ecological system, e.g. as part of a social-ecological feedback.

The third mechanism mentioned in more than 50% of the studies is the lack of alternative livelihoods. Households hit by a natural disaster that lack market access for on-farm products (Barrett, 2008; Carter et al., 2007) are for instance more likely to remain longer in poverty than less isolated households (Carter et al., 2007). Diversity with respect to income sources is cited as an important factor to avoid traps. In one study, diversity in ecological function, such as

multiple staple crops, was cited as a strategy for poverty alleviation (Titttonell & Giller, 2013).

Inequality, as a mechanism, co-occurs with lack of alternative livelihoods in all but one case. An example of this co-occurrence describes how an economically poor Amerindian Shuar community situated in the lowland of Ecuador was unable to rebuild their herds after a shock and had no choice but to rent their pastures to external 'mestizo' cattle ranchers (Rudel et al., 2013). These ranchers cleared pastures of trees to increase the production of forage, leading to degradation through constant use, nutrient leaching and soil erosion. The removal of trees created reinforcing feedbacks that prevented recovery of the previous ecological condition of the pastures, while the rent provided enough income for subsistence, but not enough to rebuild the herd. As a consequence, the Shuar community became stuck in a low-level equilibrium of well-being.

Similarly, no general consensus exists about effective strategies to break out of traps. Diversification of livelihoods and access to credit are the most frequently mentioned *strategies* (Figure 2) for overcoming persistent poverty in the development literature, for example through off-farm livelihood diversification (Carter et al., 2007), or on-farm diversification of agricultural products to move away from a singular cash crop (Swallow et al., 2009). Environmental conservation studies more often mentioned institutional change or ecological restoration, thereby breaking trap dynamics.

4. Discussion

Conceptualizations and understandings of traps are more diverse than the common understanding of poverty traps defined as a self-reinforcing stable state below an asset threshold. The limited overlap between the different conceptualizations, and lack of more integrative concepts suggests that knowledge of traps is fragmented and remains confined by disciplinary boundaries (Banerjee & Duflo, 2011). The conceptualizations across research fields emphasize different aspects of trap dynamics, and identify varying mechanisms of traps, such as reinforcing feedbacks (development economics, social-ecological), path dependency (sociology) or scale-mismatch (psychology). Corresponding to their disciplinary origin, concepts also feature different scales, from the mismatch between short-term and long-term interests at an individual scale (psychology), to system-wide feedbacks between ecological degradation and poverty (social-ecological).

On the other hand, our review of trap dynamics in rural contexts reveals surprising similarities between studies from a development economics and sustainability perspective. These studies overlap with respect to their strong focus on the aspects of reinforcing feedbacks and thresholds. This overlap may be indicative of the trap concept as used in development economics being adopted in other disciplines, as well as trap concepts having shared roots in dynamical systems theory (e.g. Holling, 1973; Barrett & Constanas, 2014). An uncritical adoption of the narrow poverty traps concept from development economics, however, bears the danger of neglecting important causes and

dynamics of persistent poverty that stem from the complex social-ecological interactions across scales that characterize rural social-ecological systems.

4.1 Gaps in the conceptualizations and understandings of poverty traps from a social-ecological perspective

Our review of mechanisms of poverty traps in rural contexts reveals major gaps with respect to the complex, adaptive and cross-scale nature of social-ecological systems. While the non-linearity and complexity of trap dynamics such as the existence of feedbacks and thresholds is well recognized, the interdependence of people and the environment and the interactions of social and ecological processes across scales have received less attention (as seen by the lack of integration of social and ecological dynamics in studies reviewed in Figure 1). A large number of studies highlight the importance of the biophysical environment for developing agricultural production by pointing to the lack of natural capital as a major driver of poverty (Lybbert et al. 2006; Barrett et al. 2006; Allison and Hobbs, 2004). However, the complex interdependencies between ecological and social processes that affect the provision and use of natural capital and thus the persistence of poverty are much less investigated. As are the contexts in which different poverty-environment relations hold, or how historical or political factors influence traps.

Trap dynamics are an emergent outcome of complex social-ecological interactions. In sustainability science studies, the reinforcing feedbacks between social and ecological dynamics, particularly between poverty and resource degradation, have recently received more attention. Much remains to be studied,

however, with respect to the conditions under which this relationship holds (Duraiappah, 1998; Leach & Mearns, 1996; Nunan, 2015). In some contexts, poverty can reinforce environmental degradation leading to more poverty (e.g. Enfors, 2012), but not in others (Chappell et al., 2013). Similarly, interactions among different types of traps across temporal and organizational scales has received little attention in the development economics or the sustainability literature (Maru et al., 2012).

A more dynamic and integrated understanding of trap dynamics requires new ways of thinking about traps (Barrett & Constanas, 2014; Lade et al., 2017). We argue that accounting for the different types of conceptualizations and understandings of trap dynamics provided by a broader, multi-disciplinary literature on traps offers opportunities for synergy and creates space for interdisciplinary inquiry.

4.2 Contributions from the broader traps literature

We build on the insights gained from our review of the traps concept in different fields, our synthesis of mechanisms of trap dynamics in rural contexts, as well as the social-ecological literature on traps to identify four aspects of trap dynamics that have the potential to broaden the concept of poverty traps to account for cross-scale and social-ecological dynamics. An overview of broader social-ecological literature on traps can be found in the Supplementary Material C. The four important causes of trap dynamics that these broader literatures highlight include i) cross-scale interactions (or scale mismatch), ii) path-dependency, iii) external factors, and iv) lack of diversity of social-ecological interactions. In the

following, we relate these aspects to the dynamics of traps in social-ecological systems, and discuss to what extent they can help lay the groundwork for a more integrated approach.

I. Traps can be caused by cross-scale interactions (Scale mismatch)

Trap dynamics can be caused by a mismatch of behavior (e.g. a social trap, Platt, 1973) and by interactions across temporal and spatial scales (Costanza, 1987, Barrett & Swallow, 2006, Maru et al., 2012). Cross-scale interactions can for instance cause poverty and contribute to its persistence when there is a mismatch between short-term economic gains and the long-term well-being of people and the planet (Costanza, 1987), or between opportunities, desires and abilities of the poor (Boonstra et al., 2016). Traps can be nested at multiple spatial and temporal scales where the interactions of traps across scales can reinforce each other (Barrett & Swallow (2006) describe these as fractal poverty traps). Farmers' resistance to adopt improved technology to increase productivity at an individual level for instance can lead to low farm-level productivity that causes larger coordination failures at a community level, which in turn enhance the reticence of the farmers to adopt new technologies (Barrett & Swallow, 2006).

Using the idea of 'panarchy', the resilience literature has highlighted the importance of cross-scale interactions in creating trap dynamics, and for transforming social-ecological systems to avoid or dissolve traps (Gunderson & Holling, 2002). Fast-changing dynamics at lower levels enable renewal and are a potential source of ingenuity to break trap dynamics at higher levels. At the same

time, higher levels can provide social and/or ecological memory to support transformation. The reverse is also true, however, where memory can become a source of inertia (for example in the reproduction of malfunctioning institutions), creating a rigidity trap (Gunderson & Holling, 2002).

Understanding these types of cross-scale dynamics is important to take account for any drivers or mechanisms that are affecting the persistence of the traps located at higher levels (e.g. institutional constraints) or lower levels (e.g. psychological constraints). The lack of a cross-scale perspective in the dominant poverty trap conceptualization may lead to ineffective intervention strategies.

II. Trap dynamics can be path-dependent

Poor initial condition is an oft-cited driver of traps, indicating that path-dependence is widely considered important but not always explicitly addressed in traps analysis. The prominence of 'poor initial condition' as a main driver of traps, demonstrates how most studies ignore the drivers that created the trap in the first place. We see this as a major shortcoming to understanding trap dynamics and therefore suggest the explicit consideration of path-dependency in understanding trap dynamics. Conceptualizations that emphasize path-dependency as a cause of trap dynamics incorporate the role of history as a causal factor into the analysis of trap dynamics. Breaking down trap processes into a series of preceding conditions and critical junctures (the moment one trajectory is chosen over another) can help identify the historical dynamics and processes that have created the trap. For example, an explicit focus on key processes in the lock-in trap of Western Australia (Allison & Hobbs, 2004)

highlights the historical structural factors that led to modernization (a critical juncture) of the agricultural sector (Boonstra & de Boer, 2013). Rudel et al. (2013) suggest that evaluations of the short-term effectiveness of big push interventions need to be combined with historical research that investigates the long-term contextual trends that may be maintaining poverty.

III. Trap dynamics can be precipitated and reinforced by external factors

In development economics and sustainability studies trap dynamics are most often explained through endogenous self-reinforcing processes and poor initial conditions, such as low asset levels. Trap dynamics are however, often precipitated or maintained by external factors (Chappell et al. 2013), including historical legacies, such as colonialism (Rudel et al. 2012). While interactions between rural poverty, globalization and global trade have been studied (Bardhan, 2006; Swinnen, 2007), the influence of these external factors on creating poor initial conditions or reinforcing feedbacks in the first place has received little attention so far in the conceptualization of poverty traps (Green & Hulme, 2005), but has been recognized for its creation of poverty (Davis, 2001).

Classical top down external interventions, such as policy reform, loans and access to credit, are frequently mentioned in the literature as poverty alleviation strategies. From a social-ecological perspective, providing a loan can break a poverty trap if it slows resource-exploitation or land degradation (e.g. Enfors, 2012), but in other contexts, credit may lead farmers to become caught up in a cycle of indebtedness that leaves them worse off than before (for example Indian farmers who are caught in a vicious cycle between debt and further

environmental degradation through the use of pesticides (Banerjee & Chowdhury, 2017).

IV. Trap dynamics can be shaped by lack of social-ecological diversity

Many studies identify the importance of diversified livelihoods as an opportunity to escape traps (Lybbert et al. 2006; Barrett et al. 2006; Cinner et al. 2009; Carter et al. 2007; Swallow et al. 2009), however, very few acknowledge the diversity of social-ecological linkages and the role diversity plays in adaptation and transformation out of undesirable states. In addition to the diversification of livelihoods, studies of agricultural systems have highlighted the important role of crop and on-farm biodiversity and corresponding biocultural knowledge in maintaining (through lack of diversity) or escaping (through enhancing diversity) traps (Chappell et al. 2013; Tittonell, 2014).

4.3 Towards an integrated, social-ecological conceptualization of trap dynamics

We propose to integrate these four aspects into a broadened traps concept for sustainability research and sustainable development. The purpose of our broadened traps concept is not to replace other approaches and models of persistent poverty, but rather to strengthen its capacity as a boundary object that can help link previously disparate fields of study. Other concepts of persistent poverty may be better suited at addressing inequality or power relations, for example (Green & Hulme, 2005).

The key characteristics of poverty traps put forward by both the economics and sustainability literature - persistence, undesirability, and internal self-reinforcement - can be used to construct a minimum level of the concept as it is commonly understood. We do not include the frequently used characteristic of existing below an asset threshold since it greatly limits the scope of cross-disciplinary synthesis. Persistence, undesirability and self-reinforcement are thus necessary conditions, but not sufficient to describe trap dynamics that emerge from social-ecological interactions characteristic for rural contexts. We propose integrating the four aspects highlighted above into a broadened concept in order to better account for the cross-scale social-ecological interactions that characterize rural poverty (Figure 3). These four aspects, together with the necessary conditions of: persistence, undesirability and self-reinforcing feedbacks, are a foundation for a more integrated social-ecological understanding of trap dynamics. Note that not all aspects will be always relevant in all situations of persistent poverty, but we hope that a broadened concept will raise awareness of the multiple causes of persistent poverty at different scales and thus provide for more integrative analysis and alleviation strategies. Linking path-dependency with external factors, for example, can be useful in recognizing legacy effects of external interventions (e.g. the process of *villagization* in Tanzania (Scott, 1998; Enfors, 2012)), and is critical in order to identify effective strategies to break the feedbacks that may inhibit change (Boonstra & de Boer 2013).

Figure 3. A broadened social-ecological conceptualization of trap dynamics including cross-scale, path-dependence, external drivers and social-ecological diversity, borrowed from disciplinary understanding of trap dynamics. The outer circle denotes the minimal, but not sufficient conditions for defining traps, and at the core, integrating these elements is the social-ecological description of traps.

A definition of traps that is too generic risks being useless, yet a concept which is too narrowly focused, e.g. on specific asset thresholds, may prevent the development of a more systemic understanding of social-ecological dynamics and its relation to poverty. Some may see the diversity of conceptualizations across the broad disciplinary literature we reviewed to be epistemologically incompatible – in that they have fundamentally different ways of viewing and conceptualizing what we refer to here as ‘trap dynamics.’ Conceptual pluralism

of the traps concept is therefore useful in order to understand trap dynamics in certain contexts or from certain perspectives. However, the intertwined nature of the sustainability problems societies are grappling with also requires integrated concepts and approaches. A broadened concept can support an analysis that integrates poverty and environment and could usefully advise environmentally sustainability poverty alleviation strategies (Lade et al. 2017).

Broadening the concept too much, on the other hand, risks missing important differences in causal mechanisms and drivers at different scales. The scope of our review mostly excluded trap studies at or global scales (since those scales were not identified by the papers reviewed). Within the studies addressing rural poverty, traps are described across different scales from individual to regional, but this does not mean that the characteristics, drivers or mechanisms of traps are the same across these different scales. A potential consequence of the narrow framing of traps at one particular scale is that the dynamics considered to create or maintain traps are perceived as internally self-reinforcing, thereby possibly ignoring factors external to the system driving trap dynamics. The Shuar example (Rudel et al., 2013) shows how external drivers can create or reinforce internal trap dynamics. An interesting extension of this work would be further disentangle which mechanisms are more likely to occur at which scales, and how traps interact across scales, either as fractals (Barrett & Swallow, 2006) or as different types of traps (Maru et al. 2012).

The limited number of papers reviewed and our focus on highly cited papers may also have led to underestimating the diversity of analyses of trap dynamics.

A lack of analytical features of what defines a trap makes it difficult to *a priori* select studies that investigate a trap, as opposed to studies that define a situation as a trap in a *post hoc* fashion. Our work could be extended by critically assessing a more inductive set of trap mechanisms across different contexts (using for example indicators of resilience in agroecological systems (Cabell & Oelofse, 2012)).

5. Conclusions

The recent literature on trap dynamics across development economics and sustainability science shares a basic understanding of a trap as a persistent, self-reinforcing, and undesirable situation. Broadening this basic understanding through integrating understanding of trap dynamics from other research fields can help address persistent poverty in relation to sustainability, allow for more effective alleviation strategies, and identify alternative development pathways.

We have identified four additional considerations that, if integrated in poverty traps conceptualizations, would better account for the complex dynamics that emerge from social and ecological relationships. First, explicitly considering the impacts of scale-mismatch both temporally and spatially enables the incorporation of cross-scale drivers that originate from levels above or below the level of analysis or intervention. Second, recognizing path-dependent processes more explicitly highlights the importance of history and timing, which may help identify barriers that need to be addressed for enabling successful endogenous development processes. Third, we propose that studies of traps and their alleviation explicitly consider how external drivers such as past interventions,

market influences of policy impacts from regional or national scales, may have contributed to the creation and maintenance of a poverty trap. Finally, a diversity of ecological and social interactions is critical for the resilience of a community to shock and ongoing socio-environmental changes as they provide sources for adaptation and transformation (Biggs et al., 2015), particularly in agro-ecological systems (Holt-Giminez, 2012).

A broader understanding of traps has important implications for poverty alleviation as it may help determine more precisely under which conditions a big push of assets to overcome a poverty threshold results in long-term improvements in sustainability and when not (Lade et al. 2017). More holistic, dynamic conceptualizations of trap dynamics are a prerequisite for ending persistent poverty sustainably.

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Supplementary Material A: List of papers reviewed for Part II

1	Allison, HE; Hobbs, RJ	2004
2	Barrett, CB.	2008
3	Barrett, CB; Swallow B.	2006
4	Barrett, CB; Marenja, PP; McPeak, J; Minten, B; Murithi, F; Oluoch-Kosura, W; Place, F; Randrianarisoa, JC; Rasambainarivo, J; Wangila, J	2006
5	Barrett, CB; Marenja, PP; McPeak, J; Minten, B; Murithi, F; Oluoch-Kosura, W; Place, F; Randrianarisoa, JC; Rasambainarivo, J;	2006

- Wangila, J
- 6 Barrett, CB; Marenja, PP; McPeak, J; Minten, B; Murithi, F; Oluoch-Kosura, W; Place, F; Randrianarisoa, JC; Rasambainarivo, J; Wangila, J 2006
 - 7 Bird, K; Shepherd, A 2003
 - 8 Cao, S; Zhong, B; Yue, H; Zeng, H; Zeng, J. 2009
 - 9 Carpenter, SR; Brock, WA 2008
 - 10 Carter, MR; Little, PD; Mogues, T; Negatu, W 2007
 - 11 Carter, MR; Little, PD; Mogues, T; Negatu, W 2007
 - 12 Cinner, JE; Daw, T; McClanahan, TR 2009
 - 13 Cinner, JE. 2011
 - 14 Coomes OT, Takasaki Y and Rhemtulla JM 2011
 - 15 Cowan R; Gunby P 1996
 - 16 Dasgupta, P. 1997
 - 17 Enfors, EI. 2012
 - 18 Glauben, T; Herzfeld, T; Rozelle, S; Wang, XB 2012
 - 19 Hanjra, MA; Ferede, T; Gutta, DG 2009
 - 20 Jalan, J; Ravallion, M. 2002
 - 21 Lybbert, TJ; Barrett, CB; Desta, S; Coppock, DL 2006
 - 22 McPeak, JG; Barrett, CB 2001
 - 23 Naschold, F 2012
 - 24 Rudel, TK; Katan, T; Horowitz, B. 2013
 - 25 Scheffer, M; Westley, F 2007
 - 26 Steneck, R S; Hughes, T P; Cinner, J E; Adger, W N; Arnold, S N; Berkes, F; Boudreau, S; Brown, K; Folke, C; Gunderson, L; Olsson, P; Scheffer, M; Stephenson, E; Walker, B; Wilson, J; Worm, B 2011
 - 27 Swallow, BM; Sang, JK; Nyabenge, M; Bundotich, DK; Duraipappah, AK; Yatich, TB 2009
 - 28 Titttonell, P; Giller, KE 2013
 - 29 Valkila, J. 2009
 - 30 Vanloqueren, G; Baret, PV 2009

Supplementary Material B: Variables for mechanisms analysis (Fig 1-2)

Variable	Definition
1. Trap name	The name of the trap
2. Traps generally defined	Key defining characteristics of the trap by the authors of the case.
3. How well were social and ecological systems integrated?	Social-ecological: took feedbacks between the social and ecological system into consideration. Social: only considered trap to be a socially emergent phenomenon. Social in SES: trap emergent phenomena of social interactions, but within an environmental context
4. Type of study	What was the research approach of the study? Theoretical, formal model, applied theory, case comparison, case study or review.
5. Research Area	All articles from Web of Knowledge are specified with research areas, which were then grouped into either development studies or sustainability.
6. Scale of analysis	Focal scale of analysis of the trap: Individual, household, local/community, regional, national, global
7. Were multiple types of traps considered?	The first part of the research (broad overview) identified various types of traps; here we consider whether various types of traps are simultaneously considered.
8. Normative assessment of traps	Are traps considered to be good, bad, or with trade-offs?
9. Trap dynamics described as:	Trajectories, fixed point, multiple stable equilibrium.
10. Shock as causal driver	Shock identified as precipitating driver of traps, yes or no.
11. Persistence	Persistence of 'undesirable' state defined as: time/duration spent in specific state, variability/return time, persistence despite altered feedbacks.
12. Drivers	Any external structural mechanisms that generate traps
13. Mechanisms	Any causal mechanism that is internal to the trap and maintaining it.
14. Strategies	Proposed strategies or interventions to break the trap dynamics.

Supplementary material C: Synthesis of traps from a social-ecological systems perspective

Author, Year	Title	Trap Name(s)	Description and contribution	Key SES take-away
a) SES literature : Dynamic SES traps				
Gunderson and Holling, 2002	Panarchy: Understanding Transformations in Human and Natural Systems (book)	Rigidity traps Poverty traps	Pathological departure from the adaptive cycle. Rigidity traps refer to inflexibility in social- ecological systems because of high and self-reinforcing connections between institutions and networks of agents with high access and holding of resources.	Dynamic

Carpenter and Brock, 2008	Adaptive Capacity and Traps	Focus on maladaptive states.	Maladaptive. Rigidity trap: strong self-reinforcing controls prevent the flexibility needed for adaptation. Whereas in a poverty trap, loose connections prevent the mobilization of ideas and resources to solve problems, impeding focus needed for adaptation.	Lack of adaptive capacity
Cinner 2011	Social-ecological traps in reef fisheries	Social ecological traps; poverty traps	When feedbacks between social and ecological systems lead toward an undesirable state that may be difficult or impossible to reverse; poverty traps are when poor people are unable to mobilize the necessary resources to overcome either shocks or chronic low-income situations and are trapped in stable or increasing poverty	Dynamic social-ecological interactions
Enfors, 2012	Social-ecological traps and transformations in dry land agro-ecosystems: Using water system innovations to change the trajectory of development	Social-ecological trap	ES are being degraded while yields remain low and people poor	Social-ecological self-reinforcement
Stockholm Resilience Centre, Insight #5 2012	Insights #5: Social Ecological Traps	Social Ecological traps	Interaction between social and ecological feedbacks can lock systems into unsustainable pathways, creating social-ecological traps	Social-ecological self-reinforcement
Tidball, Frantzeskaki, Elmqvist 2016	Traps! An introduction to expanding thinking on persistent maladaptive states in pursuit of resilience	Social-ecological system traps	Special feature inquiring how traps may influence the system or perception of system managers. Small review of social-ecological system literature on traps, pointing to the fact that understanding traps through systems modeling as become well established.	Perception of traps for NRM

			Advocate theoretical plurality. Special issue contains series of papers on traps in social-ecological systems.	
b) 4 additional conceptual factors from SES literature				
Costanza, 1987	Social traps and environmental policy	Social traps	A situation in which short-run local reinforcements guiding individual behaviour are inconsistent with the long-run, global best interest of the individual and society	Mismatch
Boonstra and de Boer, 2013	The historical dynamics of social-ecological traps	Social-ecological trap	Traps are path-dependent processes.	Path-dependence
Chappell et al., 2013	Food sovereignty: an alternative paradigm for poverty reduction and biodiversity conservation in Latin America	Poverty traps	Emphasize the importance to understand that dynamics external to a system.	External factors & Diversity
Tittonell, 2014	Livelihood strategies, resilience and transformability in African agro-ecosystems	Fractal poverty traps	Focus on diversity of rural livelihood strategies. Desirable shifts in farming systems needs to occur from level below and above system of interest.	Diversity