Chapter 13
Poverty, Payments, and Ecosystem Services in the Eastern Arc Mountains of Tanzania

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Introduction

A social trap is a situation where the short-term benefits of a decision are at odds with long-term optimal outcome (Cross and Guyer 1980). Some poverty traps are social traps. For example, rampant clear-cut deforestation may have short-term payoffs but is, in many cases a long-term net loss for both the agents of deforestation and wider society. With regard to socio-ecological systems, these traps may be spatial as well as temporal – where the actions of some in one locale may adversely affect others elsewhere (economists call these externalities). In a world of rapidly changing environmental quality, our inability to solve social traps across time and space affects the immediate welfare of millions of people living at the margin, as well as the long-term welfare of society and wildlife populations writ large.

Pressing and interrelated problems including large-scale conversion of ecosystems and the subsequent loss of biodiversity (MA 2005); increasing poverty and water scarcity (Rosegrant et al. 2003); potentially dangerous alteration in the climate system (Schneider 2001; Mastrandrea and Schneider 2004); and global fisheries collapse (Myers and Worm 2003; Worm et al. 2006) drive an urgency for integrated solutions to escape social traps which pit the consumption of one beneficiary against the livelihood of another or force decisions where rational short-term gains (e.g. agricultural extensification) undermine ecosystem services critical to long-term welfare (e.g. climate stabilization). Solutions require a deeper comprehension of the environmental infrastructure upon which human existence and social welfare depend (Sachs and Reid 2006; Schroter et al. 2005). Of primary importance is the immediate need to address the welfare of those already marginalized by regional and global economic systems and falling environmental quality.

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Doing so will require an explicit acknowledgement of (1) the complex nature of human poverty, (2) the complexity of ecological processes that deliver ecosystem services and welfare benefits, and (3) the interrelatedness of these two complex phenomena.

Here, we briefly describe these three complexities through looking at the Eastern Arc Mountains in Tanzania, one of the world's most important areas for biodiversity. We focus on human poverty in the region, the vital ecosystem services provided by the ecological systems, and the relationships between the two. We use potential payments for ecosystem services (PES) program for water to motivate a discussion on if and how such an intervention can overcome some of the social traps inherent in a system where so many people live on the margin. The trap described here is basically one where local use of resources negatively affects the regional and/or global provisioning of that service. The major complicating factor of escaping this trap is that the main agents of land degradation are acting rationally, based on their position of extreme poverty.

The Eastern Arc Mountains: Biophysical System

The Eastern Arc Mountains (EAMs) consist of 13 distinct mountain blocks stretching from Southern Tanzania to Southern Kenya (Fig. 13.1). The highest peaks in the EAMs are Lukwangule Plateau and Kimhandu Peak (>2,600 m). Northern and central blocks show two wet periods: the short wet season peaks in November and the large peaks in April with a yearly average rainfall of roughly 1,500 mm. In the southern blocks, there is one main wet season, peaking in March and April (~2,000 mm/year) (Lovett 1996). From the basins up the altitude gradient, there are transitional forests, sub-montane, and montane forests, and at the highest elevations (>2,000), there are closed evergreen forests (Burgess et al. 2007). However, montane and closed forests only cover about 3% of the EAMs. Most of these forests are protected in forest and nature reserves. The dominant land cover is miombo woodland, covering approximately 34% of the area. The woodland exists in various degrees of degradation and has lost more than 40% of its area since the 1970s (Mbilinyi et al. 2006). Roughly 8% of the EAM basins are under agriculture – mainly maize, cassava, and paddy. The remaining major land cover is a mix of bushland, grassland, and mixed cropping mosaic.

The EAMs are typified by having high biodiversity and endemism. This is reflected in their status as one the world's hottest hotspots (part of the Eastern Afromontane; Mittermeier et al. 2004) and as a globally important eco-region (Olson and Dinerstein 2002). There are over 4,000 plant taxa of which over 800 are endemic. There are at least 96 endemic vertebrate species including several endemic primates such as the sanje mangabey and kipunji monkey. The status of invertebrate species in the EAMs remains to be determined, but there are at least 43 endemic butterfly species (for a full treatment of biodiversity importance of the EAMs, see Burgess et al. 2007).

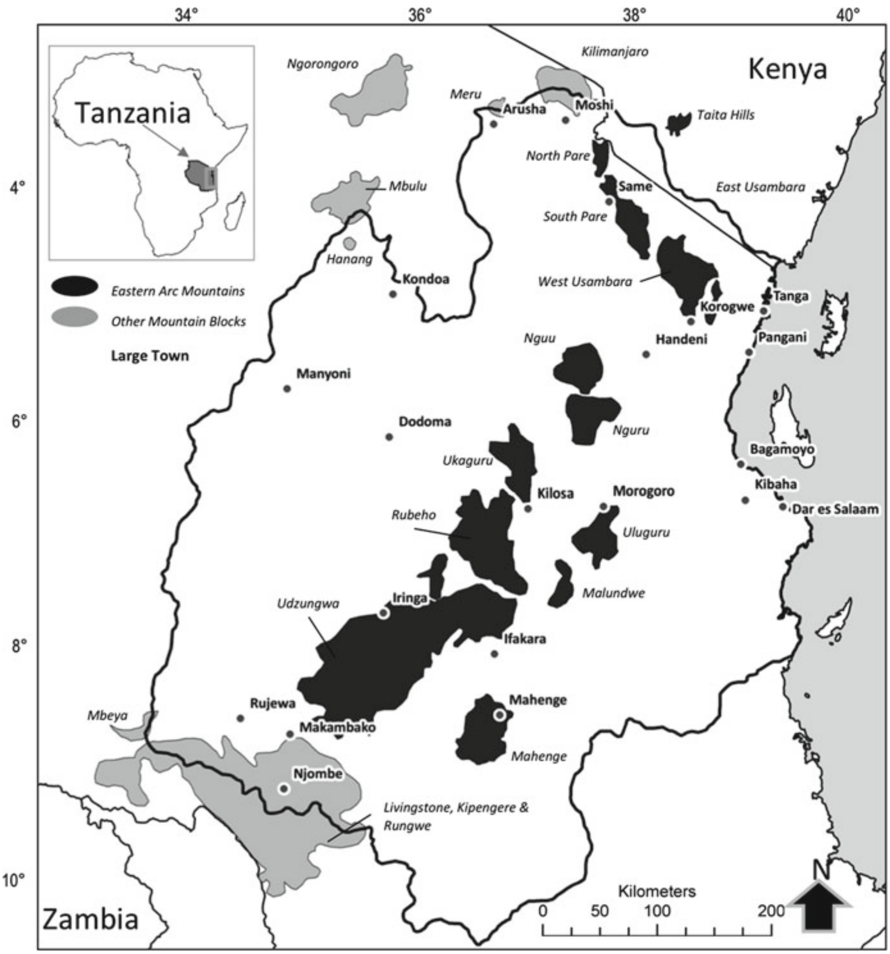


Fig. 13.1 Tanzania and the Eastern Arc Mountain blocks

Poverty in the Eastern Arc Mountains

It is well recognized that poverty is a complex phenomena (Myrdal 1957; Sen 1985; World Bank 2001). Insufficient income generation, food insecurity, water scarcity, inadequate shelter, child mortality, and access to health care are just a few indicators of impoverishment. To really address human welfare, we need to look at a suite of these indicators since meeting some minimal level of one of these indicators does not typically substitute for meeting another. The basic human "needs and satisfiers," as Manfred Max-Neef (1992) calls them, all need to be addressed to ensure that people are realizing a decent life. Nobel laureate Amaryta Sen and Martha Nussbaum based their "capabilities approach" upon this premise and specified that a person's

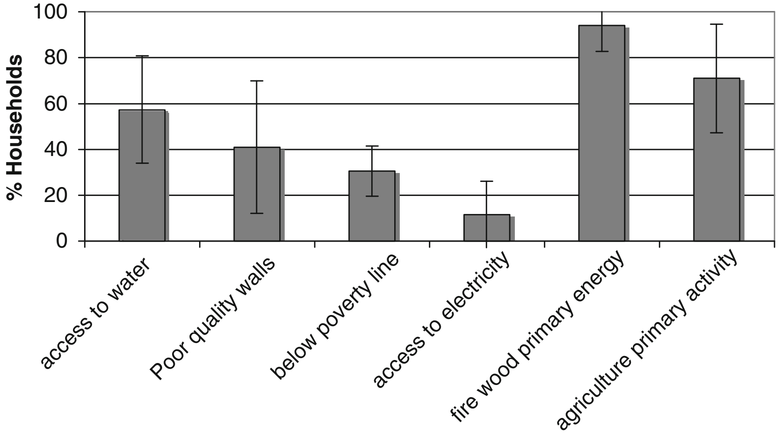


Fig. 13.2 Levels of poverty in the EAMs depicted by various indicators

ability to function in society is predicated by a capability to not only actively engage in society but also have choices as to how to develop their lives (Sen 1985).

Tanzania is a sub-Saharan country labeled as having "low human development" by the UNDP *Human Development Report* (2008). Typified by low life expectancy at birth (51 years), low formal education rates (50%), and low GDP/capita ($744 purchasing power parity (PPP)), Tanzania ranked 159 out of 177 countries in the latest Human Development Index (HDI). These country-wide statistics set the foundation for any smaller scale conservation-development work. Current research on understanding the ecosystem services produced and provided in the country is focused on the Eastern Arc Mountains and their drainage basins (see www.valuingthearc.org), and therefore sub-national poverty indicators are required recognizing that poverty is spatially heterogeneous.

Figure 13.2 shows the levels of poverty for a suite of indicators across the EAMs (bars represent ±1 SD data based on district level averages). On average across the EAM districts, 31% of the people live below the national poverty line; over 40% do not have access to an improved water source; 41% live in poor quality shelters; and less than 12% of people have access to electricity. Additionally, firewood is the primary energy source for over 90% of the people, where more than 70% of people make their livelihoods on small-scale agriculture. Based on these statistics and the national scale statistics, it is easy to say that Tanzania faces huge challenges to alleviate poverty. At the same time, there is a large variation on these averages (see SD bars). For example, although on average, 12% of people in a district have access to electricity, in rural areas (much of the region) this figure falls to around 2%. If statistics were available at higher spatial resolutions, this type of variation would appear in other indicators both across and within districts. Understanding the variation at the finest grain available is important for any type of development intervention.

What about correlations across indicators? For example, are areas with poor access to an improved water source the same as areas where there are many people

Table 13.1 Pearson correlations for various poverty indicators in the EAMs

	Poverty line	Poor quality shelter	Electricity	Health clinic access	Improved water source	Infant mortality
Poverty line	1	–	–	–	–	–
Poor quality shelter	.238*	1	–	–	–	–
Electricity	−.546**	−.423**	1	–	–	–
Health clinic access	−.164	.132	.044	1	–	–
Improved water source	−.486**	−.620**	.677**	.123	1	–
Infant mortality	.297*	.177	−.463**	−.028	−.409**	1

*Significant at the .05 level (one tailed)
**Significant at the .01 level (one tailed)

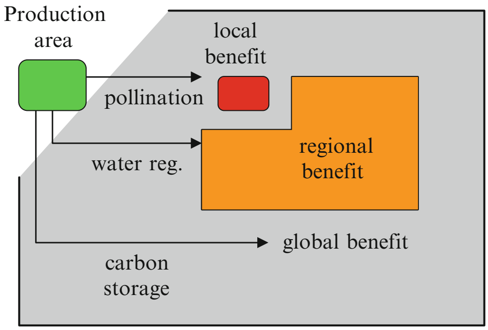
living below the economic poverty line? Table 13.1 shows the Pearson correlations for these poverty indicators, showing that while there are weak associations across some indicators, there are no strong correlations. The signs of the significant associations make intuitive sense. For example, as the number of households in a district with access to electricity goes up, the number living below the poverty line goes down. The strongest associations are cases where infrastructure for one indicator is likely to lead to the conditions to meet another. For example, as the number of households with access to electricity goes up, so does access to an improved water source – possible due to a physical connectedness by roads facilitating connectedness by water pipe and powerlines. However, based on the statistical power of these relationships, we cannot draw conclusions across different dimensions of poverty. Knowing whether poverty indicators are well correlated across a landscape is important because it allows for proxies to be used in cases where data is scarce. For example, food insecurity and average caloric intake are well correlated at the national level, which means when one indicator is missing for a country, we can use the proxy to understand the other phenomena (Fisher and Christopher 2007). When poverty indicators are not well correlated, it just adds more credence to the fact that poverty is a complex and multifaceted phenomena. It also means that interventions have to be targeted at fine scales and based on the most appropriate indicator.

This drives a question: how does the magnitude and variation of the different dimensions of poverty affect our ability to create mechanisms and interventions to avoid social traps? In order to answer this, we need to look at the socio-ecological system that defines how human welfare is affected by and affects ecosystem functioning.

Ecosystem Services in the EAMS

Understanding complexity of socio-ecological systems has quickly become a global research and policy priority (MA 2005; Sachs and Reid 2006; Sachs 2008). Under the relatively new badge of "ecosystem services," issues linking the integrity of ecological systems to human welfare have been acknowledged as critical research priorities (Carpenter et al. 2006). As discussed in other sections of this book, the

Fig. 13.3 Spatial relationships between where ecosystem services are produced and where the benefits are received



concept of ecosystem services is a multifarious concept incorporating micro-scale processes such as nutrient cycling to global scale processes such as regulation of the climate system. One way we can delineate between ecosystem services is to look at the spatial and temporal relationships between where services are produced and where the benefits are received (Hein et al. 2006; Fisher et al. 2009). This is in acknowledgment of the fact that services typically "flow" from one area to another. Some of these service flows are global in nature (e.g. climate regulation), while others are more localized (e.g. pollination). Figure 13.3 is a simple construct of a single locale producing diverse benefits across scales. Here, we look at some of the global, regional, and local ecosystem services and their benefits produced in the EAMs in order to motivate a discussion on ecosystem management, PES, and its potential relationship with poverty reduction.

Global Scale Services in the EAMs

The EAMs provide several ecosystem services and benefits at the global scale. Two of the most recognizable are carbon storage and the benefits that flow from the preservation of biodiversity. The latter provides opportunities for cultural, aesthetic, and spiritual fulfillment, as well as more instrumental benefits like opportunities for ecotourism and potential pharmaceutical discoveries. From above, we see that the biological importance of this area is nearly unparalleled. The benefits based on biological diversity are global in nature since there is the *potential* for people from all over the world to realize these benefits (actual benefits are highly dependent on access, wealth, education, etc....).

As far as the carbon storage and sequestration services are concerned, the EAMs store carbon in the majority landscape of miombo woodlands and the various other forest types. Quantification of the magnitude of this carbon store has only recently commenced, but research suggests that African tropical forest systems store a large portion of terrestrial carbon and have likely been increasing their rate of sequestration (i.e. becoming a bigger sink) to the point that this increase may represent a large portion of the world's "missing" carbon sink (Lewis et al. 2009).

Regional Scale Services

Producing and modulating water flows across the EAMs is a service provided by well functioning ecosystems in the region. Upslope vegetated landscapes throughout the EAMs help to attenuate the river flows in the wet season, providing water flows throughout the year (Doggert and Burgess 2005). Water regulation is critical for several benefits experienced across the region. In a typical year, over 60% of Tanzania's electricity generation comes from hydroelectric power plants on EAM rivers (The Economic Survey 2007). Most of this is utilized far from catchment forests, with the bulk of it supporting the coastal urban centers, mainly Dar es Salaam. Water regulation is also important for the current irrigated croplands of Tanzania, which are optimistically forecasted to expand from 200,000 ha to a million hectares by 2025 (The Economic Survey 2007). Again, timing of water flows is critical to irrigated agriculture supporting staple crops such as rice, as well as export cash crops such as coffee.

Another benefit which flows regionally from point of production and regulation with regard to water is drinking water. Most Tanzanians get their drinking water (either improved or unimproved) from rivers or shallow wells, as boreholes and deep aquifer extraction are cost prohibitive (Kulindwa et al. 2006). There is anecdotal evidence that the EAMs and their cloud capture are actually areas of water production in addition to regulation, but this assertion needs further measurement and modeling (Kulindwa 2005). Without water storage capabilities, hydroelectric power, irrigation and domestic use water all rely on ecological systems to deliver a more regular flow of water throughout the EAM basins.

Another benefit provided regionally by ecological functioning in the EAMs is fuel wood and charcoal. The production of biomass, particularly in the woodlands, is an ecosystem service utilized for charcoal production. Once produced, it is then trucked to regional centers across the country. There is some indication that up to 50% of the roughly 24,000 bags of charcoal used in Dar per day comes from the EAMs and associated basins (each bag being approximately 56 kg) (Van Beukering et al. 2007). This represents a critical role that woodland systems play in supplying urban centers with services. Charcoal is the main cooking and heating energy source for urban areas.

Local Services and Benefits

Much of the ecosystem service benefits utilized in the EAMs could be considered to be both produced and utilized on the local level. Unlike in the cities, the main energy and cooking source in rural areas is firewood. Most districts in the region show that greater than 90% of households use firewood as the main (or only) fuel source for cooking and heating. Firewood, produced in woodlands, scrubland, bushland, and farmland, is extensively collected and provides a currently un-substitutable resource for daily livelihoods.

Additional, locally produced benefits include poles for building and construction, raw materials and fibers for mats, roofing and fencing, wild fruits and vegetables, and medicinal herbs. All of these are critical to local welfare and livelihoods throughout the EAMs (Ndangalasi et al. 2007). The magnitude of such dependence is suggested in the fact that on average, 41% of houses in the EAM districts are made with poles and other natural building materials, and in over 12 districts, this figure is greater than 75%. Also, preliminary results from household surveys suggest that a large percentage of households in the Usambaras and the Udzungwas collect wild vegetables, fruits, or mushrooms from surrounding forests and woodlands. Local pollinators are also likely to play some role in pollinating mixed crops of subsistence farmers; however, the most important staple crops, such as maize, rice, and cassava, do not rely on insect pollination.

All of the services provided by well-functioning ecosystems in the EAMs embody complex relationships between beneficiaries and those actors who are most likely to affect the provisioning of these services. Because of this, management and policy mechanisms must respond to these complexities to ensure that net societal benefits of land-use change are positive. One such mechanism that is increasingly used for managing ecosystem services is the Payments for Ecosystem Services (PES) schemes pioneered in Costa Rica and discussed elsewhere in this text.

PES as a Policy Tool in the EAMs

In Fig. 13.3, we see that an individual parcel can deliver local services such as house pollinators for local crop pollination; it can deliver regional water regulation services by attenuating water flows in regional rivers for example; and it can deliver carbon storage where the beneficiaries are global in distribution. It is at the regional and global scales of delivery where systems such as PES are designed and expected to overcome social traps, or externalities. The traps exist because what is rational and necessary for local people (i.e. resource utilization and extraction) may be a net cost to wider society. In fact, preliminary evidence in a range of systems from across the world suggest that we have reached a point where the conversion of most remaining natural/semi-natural systems is like to be a net cost to society (Balmford et al. 2002; Turner et al. 2003; Naidoo and Ricketts 2006). While the decision to convert a parcel is likely to deliver dis-benefits to those living downstream of the benefit flows, the converse is also true – conserving the parcel for the benefit of downstream beneficiaries is likely to impose dis-benefits on those local actors in the form of foregone opportunities. PES systems are an attempt to overcome this trap ensuring that short-term decisions do not turn out to be long-term losses.

In these cases, the spatial distribution of costs and benefits of conservation is of critical concern. In the EAMs, it is safe to assume that forested landscapes deliver water regulation services to the district basins. Here, one of the key benefits

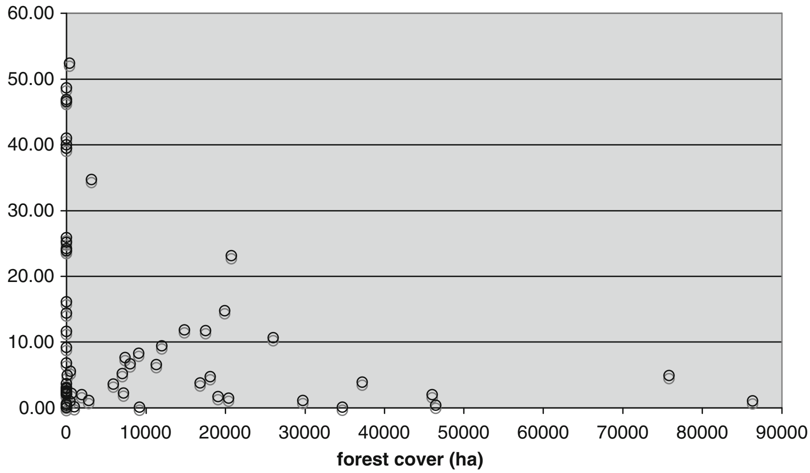


Fig. 13.4 Forest cover and household access to electricity in the EAMs (by district)

of regulating water flows is to ensure that wet season rains flow in rivers throughout the year. This is essential for Tanzania's electricity supply. The cost–benefit questions that arise are the following: (1) "Who benefits" from this provision? (2) Where is the provision generated? and (3) Who pays the cost of provision? Most of the electricity use and benefits accrue in the coastal cities where in a typical year, 60% comes from hydroelectric dams on EAM rivers. The current evidence to date supports the idea that the water regulation is a function of the forested inland districts. We can begin to dissect this relationship by plotting the percentage of households in a district with access to electricity against the area of forests in the district (Fig. 13.4). This result is intuitive, showing districts with high electricity access have low forest cover. In fact, there is a significant difference in the average access between districts with greater than 5,000 ha of submontane, montane, and upper montane forests, and those districts with less than 5,000 ha forest cover – mean difference 9.73 (±3.4) [two sample t-test, $t=3.10$, 43 df, $p < .003$]. Despite the obvious relationship, it reinforces an important consideration for environmental management – areas where forests are standing are providing a service to typically urban electricity users. This is likely to remain the case for the foreseeable future since the forecast is to rely on hydroelectiric generation for at least 50% of grid supply for the next two decades. There are several reasons that this disparity exists (historical infrastructure investment, remoteness, slope, etc....). However, that does not change the fact that any conservation of forest cover could impose an opportunity cost on those who live near the general lands and reserves where the forests stand. In short, the rural upstream people pay a cost for downstream beneficiaries, but are not compensated directly for any opportunity costs. This is the type of situation that PES is designed to overcome, but how can these payments be operationalized?

PES and Poverty Reduction

There is much debate about how and if PES schemes can be pro-poor (Pagiola et al. 2005; Corbera et al. 2007a, b; Zilberman et al. 2008; Bulte et al. 2008). However, in economics, there is a long tradition recognizing that it is very difficult to try to meet two policy objectives with a single policy instrument. A general rule of thumb is the "Tinbergen Rule" where for each policy objective, society should have a single mechanism to attempt to meet that objective. In order for PES systems to be pro-poor, defined as targeting poverty reduction, several very special circumstances need to apply. These circumstances are discussed below, but the main difficulty arises in trying to "maximize" across two objectives. If we are trying to combine the provision of ecosystem services with poverty reduction, we must have a primary policy goal. First, we have to make the assumption that forest and woodland cover help regulate water flows in rivers across the region. As mentioned above, this assumption is relatively certain, although robust measurement and modeling are still to be undertaken. Water regulation is of critical importance in an area typified by wet and dry seasons. Without the regulation functions, all of the water delivered in the wet season flows through the system in a relatively short time frame. The forests and woodlands attenuate those flows and aid in the slow release over the year. For this illustration, we also need to assume that all forest cover is equal, meaning that any forest cover delivers the same service as any other. This we know to be untrue, but the reality of the heterogeneous value of forests for water regulation is not likely to confound the example below.

So what is our primary policy goal? Prioritizing for either poverty reduction or conservation of landscapes that deliver water regulation gives us two different outcomes and therefore suggests different prioritization strategies. Figure 13.5a shows a cumulative density curve of the number of people living below the poverty line in the EAMs by district. We can see that 51% of the poor live in just 19 districts. Also, in Fig. 13.5a is the cumulative area of forested woodland represented by the districts that were optimized for income poverty. If PES is a *poverty-first* tool, then to alleviate 50% of the poverty, we need to work in 19 districts and pay some compensation to the poor under the stipulation that the associated forest cover (32% of the total) is protected for the delivery of water regulation services.

On the other hand, if we are prioritizing for water regulation (read forest cover) and hoping to get poverty reduction as a side benefit, then we are in a situation closer to Fig. 13.5b. This graph shows the cumulative density function for woodland forest cover in the EAMs. Here, we prioritize different districts based on an ecological criterion: delivering landscapes that are likely to regulate water. Any payments to protect forest cover may have knock-on poverty effects. If the payment goes toward covering opportunity costs of the poor or providing in kind services (schools, roads) then the poor may benefit. Alternatively if the payment go toward land enclosure, then the poor are likely to lose out.

However, in this case, it is not poverty driving the intervention but water regulation. In order to conserve 50% of forest cover in the EAMs, we need to work in only

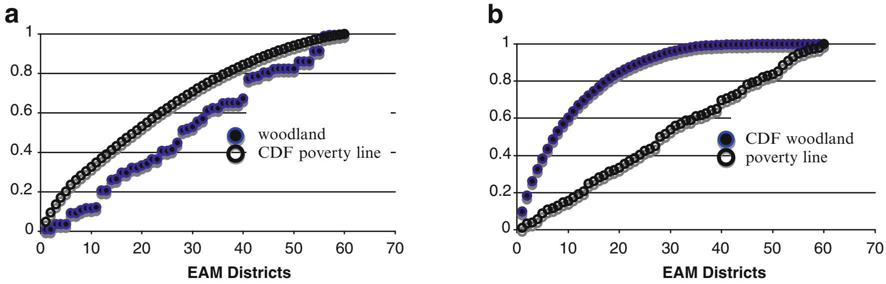


Fig. 13.5 Cumulative density curves for poverty and forest cover in the EAMs (by district)

eight districts. The associated (potential) poverty effects in these eight districts represent only 13% of those in the EAMs living under the poverty line. Back to *panel a*, if we wanted to intervene in districts and conserve 50% of forests based on *poverty-first* rule, we would need to work in 28 districts. This difference could be a critical consideration under a fixed budget where it can be assumed that the more areas you need to contract with and monitor, the greater the administration and transaction costs. Therefore, the higher the number of districts, the less the funding that goes toward ensuring ecosystem service delivery.

Both panels in Fig. 13.5 use the poverty line as the indicator of poverty. However, as highlighted in the discussion above, one poverty indicator does not necessarily correlate to other indicators. The complex and heterogeneous poverty–landscape relationship has particular consequences for any PES system. Would the same districts be prioritized if we used "poor quality houses" as an indicator? The Pearson results (Table 13.1) tell us the answer is "no." Therefore, an intervention prioritization is a function of the indicators chosen for analysis.

PES Compensation Mode

There are strong arguments that direct payments for conservation may be effective and efficient (Ferraro and Kiss 2002), but in what form should these direct payments take? In our case, providing hard currency into the areas important for regulating water flow may be affective in slowing forest degradation, but only if there are alternatives to the main drivers of forest degradation. Is cash a substitute for fuel wood collection, pole cutting for building, and agricultural encroachment? If the payment is "in-kind" such as schools and roads… we still have the same question: In an area where more than 90% of households rely on firewood for cooking and heating, does an in-kind payment cover this lost cost? In both the cash and in-kind cases, payments would have to go hand-in-hand with alternative cooking and heating energy options. The dynamic considerations include what would "cash" payments be spent on? This is an important consideration, as scenario research in the Amazon revealed that market gains from more sustainable Brazil nut collection would likely be invested in increasing land and cattle stocks by nut collectors. If that were to be the case, then more sustainable nut collection would eventually generate increased deforestation (Evans et al. 2006). These types of feedbacks would need to be considered for any long-term sustainability agenda with regard to payment modes.

Again, looking at the complexity of poverty in the region, over 40% of households rely on poles and forest products for their house construction and building needs. Here, we can see that the local benefit from forest lands (raw materials) is likely to trade off against more regional and global ecosystem services of water regulation and carbon storage. The magnitude of the lost opportunities for local agents is often considered to be the critical payment level for any PES (Naidoo and Iwamura 2007). However, a simple cash transaction ignores the complexity and necessity of meeting needs where many such actors live outside the market and few substitutes exist (Hyden 2007). In the EAMs, again, what is the substitute for the primary building resource used by the majority of households? What is the cost of obtaining this substitute?

These types of questions and considerations are complex and require context-specific investigations. Field research at different sites attest to the complex relationship between poverty and ecosystems service provision as well as the role that a PES scheme can play in modulating this relationship (Pagiola 2008; Wunder et al. 2008). Some general conclusions emerge. First, the difficulty in measuring, modeling, and monitoring the provision of any ecosystem service means that assessing the effectiveness of payments is extremely difficult (Ferraro 2008; Wunscher et al. 2008). Second, the degree to which market incentives can motivate "additional" stewardship behavior also remains an empirical question (Bowles 2008). Third, before we assume a positive relationship between payments and poverty benefits, three critical criteria need to hold (see Bulte et al. 2008; Wunder 2008 for reviews):

1. Rights to land and resources – PES systems are typically founded upon clear property rights. This ensures that payments can be made to a manager (and/or owner) of the land that delivers a stream of ecosystem services (Corbera et al. 2007a, b; Wunder 2008). In the EAMs, most of the closed canopy forests are under government control, where most of the woodlands are considered general lands. This lack of individual property rights on the general lands could be considered an impediment to PES schemes due to lack of a defined service provider. However, from an equity standpoint, this may foster a situation where any benefits from a PES could be distributed to villages attached to the general lands and therefore not dominated by large landowners. Good governance is of course a requirement for any potential equitable distribution of benefits. However, even in schemes where institutions are strong, the capture of payments by wealthy landowners has been demonstrated (Zbinden and Lee 2005). For those schemes dedicated to environmental outcomes, this is unlikely to pose a problem, but will raise flags when poverty and equity are of concern in implementation.

2. Land of high ES value – Again if the priority goal is to deliver an ecosystem service (carbon, water, etc.), any PES scheme should focus on providing the service cost effectively by seeking out areas of high service value at low costs (Ferraro 2008). This consideration has implications for how a PES can affect poverty levels. First, in order for the poor to receive any payment, they must be associated with lands that actually deliver the service of interest (Zilberman et al. 2008). To assess this, we need to understand correlations between the service of interest and poverty levels. Where there is a positive relationship, there are likely to be win-win situations. Understanding this relationship requires both the social data for assessing poverty and the ecological-economic modeling necessary to highlight areas of high ES value. While our understanding of poverty throughout the EAMs is increasing, we are still on the early part of the curve in the spatiality explicit and robust models of ES provision. However, there may be rules of thumb that already provide insight into areas of high ES provision. The literature is replete with rules of thumb as to where carbon is stored, where water capture occurs, and what areas are important for pollinators. How rules of thumb replicate reality is an outstanding empirical question, which needs to be addressed in the EAMs and in other areas where conservation development tradeoffs are likely to be the norm.
3. Opportunity costs – Another criterion for any PES to work for the poor necessitates that compensation levels are adequate to meet the opportunity costs of the ES providers. Simple monetary valuation of the opportunity costs, and monetary compensation, may work in some cases where there are fluid markets and substitutes for the activities that reflect the opportunity costs. For example, if forest degradation is driven by livestock ranching, and there are market substitutes for the nonmonetary benefits of raising livestock (milk, meat, leather), then paying ranchers their opportunity cost for not increasing their ranch lands may be an adequate mechanism. However, as is the case pointed out above, infrastructure, schools, and cash payments are unlikely to alleviate the need of the majority of households to collect firewood and poles in the EAMs. Here, the opportunity costs need to be met not in the monetary sense, but rather by understanding and providing livelihood and resource substitutes. In line with this, the poor must also not be so vulnerable such that limiting opportunities actually increases their vulnerability (Asquith et al. 2008).

There are also critical criteria for both the ecosystem service buyers and the institutional structures necessary for effective PES. These include the perception of the buyers that the ES will be provided by poor (Wunscher et al. 2008), a willingness to pay the necessary opportunity costs, and evidence that this provision is additional to what would be provided in the absence of a PES mechanism (Wunder et al. 2008). These criteria also include monitoring, verification, and adjudication structures – in short, high-capacity institutions and governance, the very criteria that are unlikely to exist in areas where there are high poverty–ecosystem service tradeoffs.

Conclusion

The role that PES can play in reducing poverty is a nuanced one, founded upon understanding the complex nature of poverty, the complexity of ecological functioning, and the interaction of these two systems. These relationships will certainly be context specific, for example, in some places, the poor are already living on degraded lands and landscapes providing few ecosystem services, in other instances, people might be income poor but have good living standards because of their local environmental condition. Here, we show that in our study area, poverty is multifaceted and that different indicators of poverty cannot be assumed to be collinear. This means that understanding any poverty–ecosystem service relationship requires a clear definition of poverty and an explicit indicator of such poverty. We also show that in areas typified by multiple dimensions of poverty, the dependence on ecological systems is likely to be very large; therefore any mechanism which has the potential to foreclose resource use options must carefully consider the actual mode of payment in PES scheme. In some cases, monetary compensation may be the most efficient. However, in cases where substitutes for essential goods are not available through the market, monetary compensation may not deliver the anticipated ES flows. We have seen that prioritization for poverty reduction determines a different intervention strategy than if we were to prioritize for ecosystem service delivery. This is an obvious result; however, it is unclear in the literature if all parties involved in the poverty-PES debate understand that there is a difference between "PES as a poverty alleviation tool" and "PES potentially delivering some poverty reduction co-benefits." Economic theory embodied in the "Tinbergen Rule" would suggest that the former stance is inefficient, that is, if you were to design a poverty reduction mechanism, would it be a PES scheme?

As has been pointed out elsewhere, there is no "silver bullet" for overcoming the very real tradeoffs between ecological conservation and human development (Ostrom et al. 2007). However, a careful understanding of the nature of any poverty–ecology relationship in a specific spatio-temporal context can highlight, if not win-win situations, at least instances where PES can help society to avoid deepening social traps.

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