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EMPIRICAL LINKAGES BETWEEN DEVOLVED TENURE SYSTEMS AND FOREST CONDITIONS: LITERATURE REVIEW

TENURE AND GLOBAL CLIMATE CHANGE PROGRAM

JULY 2014

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ACRONYMS AND ABBREVIATIONS

CBFM	Community-Based Forest Management
CBM	Community-Based Management
CC	Climate Change
CFUG	Community Forest User Group
CIFOR	International Forestry Research Centre
CIPEC	Center for Studying International Population and Environmental Change
CO_2	Carbon Dioxide
CPR	Common-Pool Resource
DBH	Diameter at Breast Height
FAO	Food and Agriculture Organization
FCC	Forest Cover Change
ha	hectares
HRS	Household Responsibility System
IAD	Institutional Analysis and Development
IFRI	International Forest Resources and Institutions
IPCC	Intergovernmental Panel on Climate Change
JFM	Joint Forest Management
km	kilometers
LGAF	Land Governance Assessment Framework
m	meters
MSU	Michigan State University
NGO	Non-Governmental Organization
PA	Protected Area
PFM	Participatory Forest Management
REDD+	Reducing Emissions from Deforestation and Forest Degradation
RRI	Rights and Resources Initiative
TGCC	Tenure and Global Climate Change
USAID	United States Agency for International Development
WRI	World Resources Institute

1.0 INTRODUCTION

The Tenure and Global Climate Change (TGCC) program, funded by the US Agency for International Development (USAID), conducts research and pilot interventions to test how improved resource tenure and property rights can facilitate successful climate change (CC) mitigation and adaptation efforts (USAID, 2013). USAID tasked TGCC to carry out a literature review of the linkages between forest condition and devolved tenure. The review has been conducted at a time when the international community is creating incentives for developing countries to reduce CO_2 emissions from deforestation and forest degradation and increase carbon stocks by enhancing forest regeneration and management (or REDD+) (IPCC, 2013; FAO, 2010). It is widely agreed that the effective execution of REDD+ requires a broad set of policies, including institutional reforms in the areas of governance, tenure, decentralization, and community forest management. Further, reforming forest tenure and governance systems is increasingly viewed as a key factor in fulfilling a whole host of development and environmental goals predicated on managing forest ecosystems sustainably (FAO, 2010; MA, 2005).

This literature review summarizes and comments on the empirical evidence related to the devolution of rights and responsibilities to forest resources and the attainment of forest management objectives. It is based on a detailed survey of studies that investigate the linkages between devolved forest tenure systems and changes in forest conditions. This review is expected to advance the interest of the USAID Land Tenure and Property Rights Division "to test the hypothesis that devolved forest rights and management slows or reverses forest degradation."

Indeed, a large body of literature has emerged and substantial progress made in accumulating empirical evidence on the role of resource governance and devolved tenure systems, in particular, in reducing deforestation and forest degradation and enhancing forest regeneration. Moreover, some preliminary attempts, including Porter-Bolland et al. (2012), Casse and Milhøj (2011), and Robinson et al. (2011), have reviewed this body of work. However, these reviews are limited in scope and narrow in their approach; few of them can be viewed as critical assessments of the existing literature in terms of understanding the appropriateness of the underlying perspectives, the quality of the data and variables, and the reliability of analytic results.

While challenging, this study aims to take stock of what has been investigated and achieved and identify strategies to overcome research shortcomings. Before proceeding, it is necessary to define both "devolved tenure" and "forest condition" and describe the approach to and organization of this literature review and synthesis.

DEFINITIONS OF KEY CONCEPTS

Devolved Tenure and Community Forestry

Scholars previously tended to define decentralization and devolution loosely in the context of natural resource governance. As noted by Tacconi (2007) and Andersson et al. (2004), the two concepts are often used interchangeably in the literature,[1] referring generally to the transfer of control over resources from the state to local communities and even individuals (R ibot, 2002; Agrawal and Gupta, 2005; Bruce et al., 2010), and from the central government to local government (Kaimowitz et al., 1998; Larson, 2002; Andersson, 2003).

[1] For ease of discourse, we will use the term devolution as much as possible hereafter. Also, note that some scholars consider devolution as a sub-category of decentralization, involving decentralization of decision-making authority as opposed to decentralization of implementation tasks (Bruce, 2014).

However, scholars have recently attempted to better define devolution from the perspective of resource tenure. Larson et al. (2010) clarified that forest tenure determines who is allowed to use which resources, in what way, for how long, and under what conditions, as well as who is entitled to transfer rights to others. Citing Schlager and Ostrom (1992) and Agrawal and Ostrom (2001), they expressed the commonly used concept of tenure as a "bundle of rights," ranging from access and use rights to management, exclusion, and alienation. Depending on the exact combination of the specific rights granted to and held by a community collectively or individually within it, there can be owners, proprietors, authorized claimants, and authorized users. In practice, tenurial situations "range from tree planting agreements and benefit sharing arrangements within industrial logging, to a variety of community-based forest management (CBFM) schemes and full-blown titling of large territories" (Larson et al. 2010, p. 80).

The assertion has long been that both the transfer of resources from government to communities/individuals and from central to local government would lead to more efficient, flexible, accountable, equitable, and participatory outcomes. Thus, both approaches are of general interest (Agrawal and Ostrom, 2001; Andersson et al., 2004; Tacconi, 2007). Given these distinct possibilities, it is clear that devolution may not necessarily lead to CBFM, even though CBFM is one form of devolution.[2] As noted by Agrawal et al. (2008, p. 1460), "decentralization of forest resources around the world is occurring for the most part under the general rubric of community-based conservation, where communities and their representatives gain varying degrees of collective control over forest resources." Regardless of the specific type of devolution, in most cases it is not pure community "ownership" that matters (i.e., the transfer of most rights in the bundle, in particular including the right to sell or alienate the resource), but the emergence of new forms of common-pool resource management, based around joint forest management, co-management, or participatory management arrangements (Ostrom and Nagendra, 2006; Larson and Soto, 2008).

This movement toward devolution of some, but not all, rights to local levels has evolved based on the existence of traditional access to and use of forest resources by local and indigenous people on the one hand and the poor outcome of centrally managed forest systems in many cases on the other (Sunderlin et al., 2008; Ribot, 2009; Bruce and Knox, 2009). Bartley et al. (2008, p. 164) further noted that devolution itself is "a process of expanding the number of levels that are authorized to make and enforce collective decisions—of increasing complexity in the nesting of institutional rules." So, it seems unrealistic to think that policies promoting devolution of tenure will result automatically in transformative changes of resource governance on the ground. Instead, devolution entails a long, complex, and often arduous struggle between government, local people, and other stakeholders (Bruce et al., 2010).

It may be more meaningful to consider devolution in terms of the transfer and exercise of various rights as part of a broader package of forest tenure reforms. It is important to be mindful of what one means by devolution; otherwise, CBFM is devoid of institutional context. Experience shows that the devolution of rights and control to forests from the state to a community or individuals through policy reform processes can be realized only if there are favorable conditions in the political, socioeconomic, and biophysical realms. As such, it is worthwhile to consider the influence of institutional variables as "mediating" the roles of these factors in determining the resource governance outcome (Ostrom, 2007; Bartley et al., 2008).

Forest Condition

The term "forest condition" is loosely used to describe not only the dynamics of forest cover, but also forest stocking (volume, biomass, or density) and even the status of forest structure, diversity, and health (Davis et al., 2001). Rigorous measurement should derive all of these indicators, as well as their changes over time. Forest inventory and monitoring systems are set up to use rigorous scientific methods and permanent

[2] In the literature, CBFM may cover local user-group initiatives, indigenous reserves, and sacred forests, but it does not include private plantations, concessions, or individual tree-planting. In the authors view, however, the latter cases should not be ignored in any serious attempt of evaluating the impact of forest tenure and governance reforms, given the roles they have played in modifying forest conditions one way or another.

sampling plots to measure forest condition at both the national and more disaggregated subnational (e.g., provincial, municipal, and county) levels.

The Food and Agriculture Organization of the United Nations (FAO) publishes regular global and regional forest resource assessment reports that summarize the extent of forest and other wooded lands, amount of carbon storage in forest biomass, area of forest affected by fire and other disturbances, and rate of removal of wood and non-wood forest products (FAO, 2011). Much of this data is derived from national forest condition assessments structured around multiple indicators of forest condition. Particular research questions often drive the choice of indicators. For example, if the interest is in rates of forest degradation or even reforestation, then measuring the extent and percent of forest cover should suffice. However, if the interest is in assessing changes of volume, biomass, or carbon storage, then measuring growing stock, incremental rate, and/or stocking level should be the focus. If the focus of research question is on ecosystem health, then determining incidences of disturbances and stand structure in terms of age, density, canopy, and ground debris should be the focus of measurement.

The use of the term "forest condition" thus varies enormously—as does even the definition of a "forest." These terms are derived from forest management objectives, analytical methods, and context (Chomitz et al., 2007). Unfortunately, few studies investigating the linkages between tenure and governance examine forest ecosystem health. As a result, studies related to forest governance rarely look at metrics like species diversity indices, forest disturbance trends, and forest structure indicators such as size/age distribution, density, canopy cover, patch-fragmentation, and ground debris. At a minimum, it is essential to distinguish between planted forests (plantations) and natural forests.

The advent and application of geospatial technology (e.g., remote sensing, including satellite imagery and geographic information systems) is a major development over the past two decades that helps to derive information about the historical and current states of forest cover. Because it has previously been expensive to acquire and process images, initial studies were largely confined to quantifying forest extent in the context of deforestation/reforestation and land use and land cover change. More recently, improved image resolution, computing speed, and data storage capacity, as well as the reduced cost of image acquisition and processing enable the routine deployment of geospatial technologies to measure a host of forest condition indicators like forest stock, density, structure, and in some cases, biodiversity. It is now possible to measure, without significant technical difficulty, rates of forest degradation and reforestation (Hansen et al., 2013; Matricardi et al., 2007). Where forest inventory data is available, geospatial data can complement this more classical source of data and expand the scope of forest condition analysis.

As discussed below, regional-level studies linking devolved tenure systems and forest conditions tend to present data from forest inventories, satellite imagery, or both. However, many of the studies are based on perceived, or subjectively rated, forest condition indicators (poor, average, or good) or vague indicators (improved, remained the same, or worsened). Regardless of the scale of research, to date, most studies have linked the current tenure and governance arrangements to the *current* forest conditions, thus ignoring the time lag between policy changes and biophysical impacts. Moreover, a majority of these studies has simply examined the extent and change in forest cover; growing stock, density, and removal are rarely considered, let alone forest diversity and health.

Here, one should acknowledge that because forest devolution and the associated concepts have a longer intellectual history than REDD+ or forest carbon literature, a large portion of the reviewed literature has been generated without carbon emissions reduction or stock enhancement in mind. That does not mean, however, that the earlier studies of the relationships between devolved tenure systems and forest conditions are less relevant to the current discussion of forest-based climate change mitigation. Because forest condition determines forest ecosystem services, including carbon sequestration and storage, an understanding of tenure systems and forest conditions will have direct applications to REDD+. This study acknowledges that there are a many additional outcomes of tenure devolution that impact economic livelihoods and well-being; however, for the purpose of this research, the study narrowed its focus to forest condition.

METHODOLOGY OF REVIEW AND SYNTHESIS

The primary purpose of this literature review is to summarize the empirical evidence derived from relevant and robust quantitative studies on the linkages between devolved tenure systems and forest condition.[3] Therefore, publications that deal solely with forest conditions and/or their changes (deforestation and forest degradation, and/or forest regeneration) over time, and those that cover merely the devolution of forest ownership and other rights are not considered. The review includes case study literature in English but excludes theoretical treatises. Literature on this issue in other languages is not included simply because of cost.

The second section summarizes each of the two identified strands of the primary literature and evaluates the strengths and weaknesses of individual studies. Section 3 follows with a summary of the representative case studies by region and an assessment of meta-analyses. The next section (4) presents evidence from selected countries—Nepal, India, and China in Asia; Mexico and Brazil in Latin America; and Niger and Tanzania in Africa—featuring varied responses to devolution processes to illustrate the causal linkages and underlying contexts. The fifth and final section examines research advances, compares the advantages and disadvantages of different approaches and databases, articulates the knowledge gaps that still remain, and suggests ways forward to advance knowledge and facilitate action on policy and practice.

Notably, the review covers not only peer-reviewed articles and books but also "gray literature" reports and other materials generated by international agencies and donors, as well as diverse research programs and projects. The research began by examining outputs generated by such institutions as International Forestry Resources and Institutions (IFRI); the Center for the Study of Institutions, Population, and Environmental Change (CIPEC); the Center for International Forestry Research (CIFOR); and the World Resources Institute (WRI). Next, regional analyses of a more academic nature were undertaken. Finally, the research tracked literature citations from the initial pool of studies.

Over the last two decades, especially since 2005, a large body of relevant work on the relationship between devolved tenure and forest condition has been accumulating at an accelerated pace and with increasing rigor. This body of work has unfolded along two distinct but complementary lines of inquiry: local-level examination of closely coupled forest conditions and specific institutional variables (e.g., rulemaking and monitoring), which typifies studies conducted by the IFRI affiliates; and regional-level analysis of resource conditions against a broad array of institutional and other measures (e.g., different tenure systems or scenarios of before and after devolution), which is reflected in some of the CIPEC publications. In the IFRI case studies, a forest is the basic unit of observation and analysis; in the CIPEC analyses, a municipality, a district, or a county is the basic unit of observation and analysis. In addition, scholars at CIFOR, WRI, and other organizations have contributed interesting case studies, qualitative evidence, and theoretical refinements. These studies all agree that because rights, rules, and institutions function within a particular social, economic, and ecological context, a forest tenure factor is but one of the many variables that could drive changes in forest conditions (Ostrom, 2007; Chomitz et al., 2007).

A couple of caveats are in order. First, the analysis presents some overlapping references and citations throughout the literature review. Second, while this review has an implicit objective of understanding the impacts of CBFM on forest conditions, it does not discount or ignore other forms of devolution to public and private entities. This is not only because they constitute a large part of the literature, but also because these experiences can inform effective CBFM implementation.

[3] The authors only reviewed studies written in English; they do not cite the literature on this subject presented in French, Spanish, and other languages.

2.0 LOCAL-LEVEL STUDIES

Since 2005, at least eight influential papers link tenure regimes with forest conditions at the local level (see Table 1 of Annex A for a listing). These studies stress the importance of rulemaking, enforcement, and monitoring on improved forest conditions, among others. Gibson et al. (2005) authored the first one, ***Local enforcement and better forests***. Building on Ostrom (1990) and other works on the governance of common-pool resources (CPRs), the authors posited that regular monitoring and sanctioning of rules, or rule enforcement, is a necessary condition for successful resource management. In their own words, "where rule enforcement is regular, we expect better forests; where it is sporadic or nonexistent, worse forests." They tested this proposition by using data from 178 user groups and pairing rule enforcement with other factors, such as social capital, formal organization, and dependence on forest products.

The authors defined rule enforcement as the regularity with which individuals in a user group monitor or sanction others' rule conformance. Regularity was measured by how frequently the user group undertakes monitoring and sanctioning efforts. The frequency of cooperative activities such as harvesting, processing, marketing or sales, and financial contracts measured the group's social capital. Summing the user ratings and then dichotomizing at the mean derived the group's dependence on forest for food, timber, and firewood. A dummy variable (1 or 0) indicated whether the group was a formal organization or not. Forest condition was dichotomized based on rankings by users (abundant or sparse) and by foresters (subsistence and commercial values). They concluded that "regardless of levels of social capital, formal organization, or forest dependence; regular monitoring and sanctioning are strongly associated with better forest conditions."

Another similar study was Hayes (2006), titled ***Parks, people, and forest protection: an institutional assessment of the effectiveness of protected areas***.[4] The author began by asking three questions: (1) Are parks more effective than non-parks in maintaining better forest condition? (2) How do rules for forests and forest products relate to forest condition? (3) How prevalent are locally recognized forest rules in parks and non-parks? To answer the first question, Hayes compared the forest vegetation densities between the two datasets (76 parks and 87 non-parks) to determine whether they differ significantly to address the first question. Next, a correlation test was done between forest vegetation density and each of four institutional variables—user group identity, forest product rules, user-defined rules, and user-defined sanctions—in answering the remaining two questions.

A local forester ranked the vegetation density of a forest again in relation to other forests in the same ecological zone, ranging from very sparse to very abundant. Forest users stated the forest rules governing the use of the forest. User rulemaking reflected the percent of total user groups responsible for making rules about a forest. User-defined sanctioning represented the percent of products for which user groups can decide the appropriate sanction when a harvesting rule is broken. The results were "striking." First, there was no significant difference found between the vegetation densities of the two types of forests. Second, not only the presence of rules but also the ability of the users to make the rules for the forests correlated positively with vegetation density. In addition, parks had significantly fewer product rules than non-parks, and the user groups were generally unable to establish the forest rules in parks. Finally, the author discussed the ramifications of this study in terms of the effectiveness of designated protected areas (PAs) and the importance of rules created and recognized by forest users.

These are two of the early quantitative studies. Their focus on rulemaking and enforcement deserves credit, and the variables used seem conceptually sound. However, the analysis is based on simple analyses that look

[4] The words "park" and "non-park" are misnomers in this context, because the actual comparison was between protected areas (PAs) and non-PA. Nevertheless, those are the terms used in several articles. In fact, comparing the effectiveness of PAs with non-PAs, especially with CBFM, has attracted a great deal of attention and thus become a large part of the literature.

for correlations using cross-sectional data (many observations from a single point in time), with a limited set of variables that were not well defined or enumerated. In the words of Agrawal and Chhatre (2006, p. 150), "…empirical analyses that focus only on a restricted set of causal influences likely inflate the significance of the variables they consider even as they ignore the relevance of excluded variables."

Additionally, these studies have raised several questions: Why did they use perceived, not measured, forest conditions? Can vegetation density adequately reflect the functions of PAs and be a representative indicator for comparing PAs with non-PAs? Is it sensible to say that user groups were unable to establish the forest rules in PAs, if they were designated to serve non-commercial purposes (e.g., harboring flora and fauna and conserving unique ecosystems)? What is the exact nature of the rulemaking or monitoring? How appropriate was it to ask the users to rate their dependences on various forest products and then lump them together? Why did they give little descriptive information regarding the sample user groups or forests? These are some of the limitations associated with these studies and the data on which they are based. `

Similarly, in ***Explaining success on the commons: community forest governance in the Indian Himalaya***, Agrawal and Chhatre (2006) asserted that "Much of the literature relies on a case study or comparative case study approach. Statistical analyses are rare. Knowledge about the magnitude, relative contribution, and even direction of influence of different causal processes on resource management outcomes is still poor at best." Then, they set out to address the knowledge gaps by conducting a statistical analysis of 95 cases of decentralized, community-based forest governance in Himachal Pradesh. They defined forest condition as a function of biophysical, economic, demographic, institutional, and socio-political variables. Their Forest Condition Index was based on group responses with a variable whose value ranges from 1 (very bad) to 5 (very good). A large number of independent variables (over 20) were included in a single regression. Their results showed "the influence of biophysical factors on socio-cultural conditions and resource governance outcomes."

This is an early "large-N" (large sample size) study based on an ordinary least squares regression and cross-sectional data. It is commendable that the authors considered the influences of biophysical, economic, demographic, and socio-political factors, as well as the role of institutional variables, in jointly determining the resource outcome. Like Gibson et al. (2005) and Hayes (2006), however, the authors enumerated many of the socio-political and institutional variables with simple indices that may not have been well defined. As they partially admitted, for example, "community perceptions as a proxy for forest condition introduce a measure of subjective error." The specification of the regression model was spurious with the indiscriminate inclusion of many variables, and some of the coefficients have unexpected signs (rainfall, guard, and co-manage) or trivial magnitudes.

In ***Drivers of reforestation in human-dominated forests***, Nagendra (2007) used a dataset of 55 forests (12 national forests, 25 community forests, and 18 leasehold forests—3 tenure regimes) from the middle hills and Terai plains of Nepal to examine the factors associated with forest clearing or regeneration. The dependent variable is the change in forest density (again, users provided assessment of changes in tree, bush, and ground-cover density over the past five years; information on these variables was then combined to produce a composite three-point index of whether the density has increased, stayed the same, or decreased over time). She started with 17 drivers in five categories. Arguing that tenure regime is the most relevant independent variable, she quickly eliminated other tenure-associated variables from further consideration, leaving eight: tenure regime, distance of settlement from the forest, group size/forest ratio, monitoring, social capital, leadership, involvement of users in making rules, and involvement in forest maintenance. This set was still too large to examine for associations due to the sample size. Given that the degree of monitoring is associated with settlement distance from the forest, social capital, involvement of users in making rules, and forest maintenance, these four variables were removed as well, resulting in a set of four independent ones in her formal analysis: tenure regime, monitoring, user group/forest ratio, and leadership.

Her results affirmed the central importance of tenure regimes and local monitoring for forest regrowth. In addition, user group size per unit of forest area is an important explanatory factor of forest change. She then stated, "Such large-N, comparative studies are essential if we are to derive more complex, nuanced, yet

actionable frameworks that help us to plan better policies for the management of natural resources." It is nice to start with a broad framework in the spirit of Ostrom (2007) and tackle the tenure-forest cover linkage directly. However, it is a simple association analysis, with forest cover, tenure, and other variables poorly defined and approximated, especially the use of dummy and categorical indices based on responses. No effort was made to look into the underlying differences of tenures or forest cover types. The removal of many identified (biophysical and socioeconomic) variables was subjective and unfortunate and could have resulted in biased findings. Finally, this study has set a precedent for the narrowly focused examinations of the tenure and forest cover linkages that follow.

In ***Forest commons and local enforcement***, Chhatre and Agrawal (2008), drawing on commons data of 152 forests in nine countries, found that higher levels of local enforcement have a strong and positive but complex relationship to the probability of forest regeneration. Indeed, they asserted that "This relationship holds even when the influence of other factors (user group size, subsistence and commercial importance of forests, size of forest, and collective action for forest improvement activities) is taken into account…The research, using data from diverse political, social, and ecological contexts, shows…the importance of enforcement to forest commons..." Further, they noted that forests with a higher probability of regeneration are likely to be small to medium in size with low levels of subsistence dependence, low commercial value, high levels of local enforcement, and strong collective action for improving the forest quality. Conversely, larger forests in the sample with high subsistence dependence, low enforcement, and high commercial value are more likely to become degraded.

In their multinomial logit model, the dependent variable was "Change in Forest Condition over the Last Five Years," a categorical proxy denoting three outcomes—degradation, no change, and regeneration—that was derived from interviews with local users, forest guards and monitoring agents, and forestry specialists. Level of enforcement (ranging from none = 0 to strict = 5); improvement activities in the forest (yes = 1, no = 0); and commercial value of the forest (ranging from very low =1 to very high = 5). The modeling approach was neat and the graphic presentation of their findings was masterful. Nonetheless, again, problems existed with their data and variable definition including the use of dummy and categorical indices based on responses. In addition, little effort was taken to control the geographical variability, and the absence of some basic biophysical and social-political variables is troubling. Finally, it begs the questions: What rules are enforced? What element of a forest is improved? Is the strong generalization warranted?

In ***Trade-offs and synergies between carbon storage and livelihood benefits from forest commons***, Chhatre and Agrawal (2009) used basal area of trees per hectare (ha) as a measure of above-ground carbon storage and contributions from the forest commons to subsistence needs of local users as a measure of livelihoods—a composite index of proportions of firewood, fodder, green biomass used as fertilizer, and timber for domestic consumption. Then, they divided the whole sample into four categories of joint outcomes: low carbon storage and low livelihood benefits, low carbon storage and high livelihood benefit, high carbon storage and low livelihood benefits, and high carbon storage and high livelihood benefits. Next, they tried to predict membership in one of the four joint outcome categories using forest size, decision-making autonomy, and forestland ownership through a multinomial logistic regression analysis of 80 forests in 10 countries. They reported that the area of the forest commons and the degree of rulemaking autonomy are both positively associated with the outcome of high carbon storage and livelihood benefits and negatively associated with the outcome of low carbon storage and low livelihood benefits. However, ownership of forest commons had a trade-off relationship with carbon storage vs. livelihood benefits, which is inconsistent with what Nagendra (2007) found. Thereafter, they discussed the implications of their findings in terms of improving livelihood and carbon storage benefits from devolution of forest governance by government and gaining greater rights to make rules by communities, as well as the ongoing debates about the implementation of REDD+ initiatives.

Because ownership and local autonomy in rulemaking played an important role in their analysis, they provided an extended account of how these variables were constructed. In the IFRI database, a nominal variable with seven categories indexes different ownerships. Two of these categories pertain to ownership by

governments at different levels, whereas the others capture variations in the form of communal ownership across different countries. They created a new ownership dummy (1 where governments own the forest, and 0 for the remaining categories). As they noted, this inevitably reduced the variation in types of ownership to a dichotomy. But they justified this by saying that they were interested in the applicability of their findings to ongoing devolution reforms around the world. Another variable represents the level of strictness of conservation measures adopted in relation to the forest, as perceived by a cross-section of users. It has four categories, ranging from 1 for "too restrictive" to 4 for "nonexistent," with 2 for "about the right level of conservation." From this information, the authors simplified this variable, dividing the sample into communities with low vs. high levels of autonomy in making management decisions about the forest commons (1 for "about the right level of conservation" and 0 otherwise). But it is far from straightforward to appreciate how communities with sufficient autonomy will create rules based on local knowledge of the resources appropriate for conservation. Thus, treatment of the strictness of conservation measures as an indication of community autonomy is difficult to understand.

Additionally, can basal area be a good proxy for biomass and thus carbon stock? How sensible is it to talk about the tradeoff between the two benefits from the perspective of locals, given that their decision and behavior may have little to do with carbon storage, at least in the past? To their credit, at the end of their paper, they acknowledged the following (p. 17669): "We should sound a cautionary note, however. Our statistical treatment of local autonomy in making rules and community vs. central government ownership has required that we greatly simplify the complexity of these concepts and the local practices they denote. There are many nuances within community and government ownership of resources as also in the ways local autonomy in rule making is practiced. Collection of better data in the future and using this data to further nuance the treatment of ownership and autonomy will help deepen and further enrich our findings."

In ***Governing community forests and the challenge of solving two-level collective action dilemmas—A large-N perspective***, van Laerhoven (2010) used a cross-national dataset to show that (1) monitoring—and to a lesser extent, maintenance—is correlated with improving forest conditions; (2) social capital, organization, leadership, and autonomy contribute to the development of institutions for collective action; and (3) two-level (within and between groups) collective action dilemmas may hinder the emergence of effective governance regimes, which is a novel idea. His work included two stages. In the first stage, he examined whether or not governance matters in forest condition change. In the second stage, he treated monitoring as the dependent variable to explore the likelihood that good governance regimes would emerge.

Groups of respondents using the forests were asked whether tree density, the density of shrubs and bushes on the forestland, the density of the ground cover on the forestland, and the area over which vegetation exists, had changed during the five years. If the sum of the responses to those four questions was positive, he coded the forest as "1" (improved); if the score total was negative, the he coded the forest as "0" (decreased). In the case that the sum of the answers equaled zero, he further checked if forest conditions were evaluated overall as above or below the regional average. If no net change in forest conditions was reported, but the forest was in good condition to start with, a "1" was assigned. If no net change was reported and the forest conditions were below average for the region, a "0" was assigned. The IFRI database contains 10 rules regarding the use of forest products by a user group (e.g., restrictions concerning location, timing, and techniques of harvesting, and rules regarding transport, processing and commercialization). This variable was operationalized by calculating the percentage of IFRI rules applied in the area. Similarly, if a user group indicated that they engaged in either seasonal or year-round monitoring of the forest, the monitoring variable was coded as "1", and "0" otherwise. The maintenance variable measures the number of tasks (11 in total) that the forest user group undertakes, including the planting of trees and clearing of undergrowth.

The key findings were summarized in two words: governance matters! That is, forests used by groups that have rules and engage in monitoring and maintenance are more often improving than forests used by groups that do not engage in these expressions of governance. Specifically, being organized, having learned from other collective problem-solving experiences, having leaders, and having the autonomy to craft their own governance regime are among the variables that seem to contribute significantly to a group's ability to

overcome collective action dilemmas related to initiating, adapting, and sustaining an effective governance system. Further, two-level collective action dilemmas complicate the organization of community forest governance. A group that is organized and relatively autonomous, and has experience with collective problem solving and a leader, has high odds of solving collective action dilemmas.

Obviously, these are some sweeping conclusions, but they were reached despite the model misspecification and data problem as well as the fact that some of the coefficients are either insignificant or have the wrong signs. Moreover, the approach looks naïve with the neglect of endogeneity in monitoring and maintenance, and the separate estimations of the two equations. Again, it is unclear: Which rules are more important? What maintenance is more consequential? What is the linkage between governance rules and the biophysical conditions of the forest lands?

In ***Social and ecological synergy: local rulemaking, forest livelihoods, and biodiversity conservation***, Persha et al. (2011) first claimed that "…current policy responses, particularly in terms of explicit management for trade-offs or synergies across multiple social and ecological goals, are seldom based on careful analysis or evidence of factors that lead to improvements across desired sets of social and ecological outcomes together." Next, they examined biodiversity conservation and forest-based livelihood outcomes using a dataset on 84 sites from six countries in East Africa and South Asia. To that end, they used an estimate of tree species richness as an indicator of forest biodiversity and the percent of households that depend on the forest for subsistence needs (from "0" to "1" rated by respondents) as an indicator of livelihood contributions of the same forest. Three joint outcome categories resulted: (1) species richness and livelihoods contributions are both above average (sustainable forest systems); (2) species richness and livelihoods are both below average (unsustainable forest systems); and (3) either species richness is above average relative to other forests and livelihoods are below average, or vice versa (tradeoff forest systems). Then, they looked into how the hypothesized social and ecological factors affected the observed outcomes, using ordered logistic regression analysis.

Only three independent variables were included in their model: forest size; formal participation, as conferred through policy, of local users in rulemaking (called "rulemaking participation"); and dependence on the forest for extractive commercial livelihoods (primarily charcoaling, small-scale timber harvesting, fuelwood, and collection of non-timber forest products for cash income). Their results demonstrated that forest systems are more likely to have sustainable outcomes when local forest users participate in rulemaking, whereas unsustainable forest system outcomes are more likely when users do not participate. The size of the forest and the extent to which the forest provided commercial livelihoods to households are also important factors associated with obtaining either sustainable or unsustainable forest system outcomes, with a higher likelihood of sustainable outcomes as forest size and commercial livelihoods dependence increase. Therefore, working toward formal participation of local forest users in rulemaking processes for the use and management of forests from which they draw their livelihoods is an important way to increase the probability of obtaining more positive outcomes across social and ecological dimensions.

The basic method, data, and findings of this article closely resemble those of Chhatre and Agrawal (2009). Done appropriately, their results can be of tremendous benefit. However, the question is whether the data, variables, and analytic approach are sound. For one thing, simple indices based on subjective perception, instead of objective measurement, may not be very useful and robust to support those conclusions. The model was poorly fitted (the model does not describe the data very well). Again, we do not know what rules were made and why only three independent variables were included.

3.0 REGIONAL-LEVEL STUDIES

The interface between forest health and socioeconomic variables like resource tenure has been carried out over the years at the regional level around aggregate units of geopolitical bodies. In Latin America, the governance entity of the municipality is often used, whereas the focus of analysis may be the district, county, or some other entity in Africa and Asia. In addition to dealing with devolution from central to municipal, district, or other local governments, these studies also encompass investigations of devolving resource control from government to private, as well as community, entities. Overall, these regional studies highlight the significance of the nexus of rights, commitments, and capabilities of the new management agents to the forest dynamics, induced by devolved tenure, tenure security, and/or policy settings created in the process. The discussion below summarizes the identified regional-level studies, also listed in Table 2 of Annex A.

In ***Forest fragmentation and regrowth in an institutional mosaic of community, government and private ownership in Nepal***, Nagendra et al. (2008) analyzed forest change in an area of Nepal that represents a delicate balance between sustaining the livelihood needs of a sizable human population dependent on forest products, and protecting important wildlife and other natural resources. The study area, a portion of the Chitwan Valley, represents what may become a common institutional mosaic in countries that have a population reliant on forest products for their livelihoods: a national park, a park buffer involving participatory forest management, scattered patches of designated community forest, and large areas of adjacent landscape of mostly private landholdings under agricultural practices. Using Landsat images from 1989-2000, they estimated land cover change in each of these management zones using landscape ecology metrics and quantified proportional distributions of land cover categories—the transitions of no-forest, open forest, and dense forest over time (leading to stable no forest, stable forest, deforestation, degradation, regrowth, and reforestation). Indices were also used to assess forest fragmentation.

The results displayed significant differences in land cover dynamics and spatial patterns between these "ownership classes." That is, community-based institutions (participatory management programs in the park [i.e., reserve], buffer, and the designated community forests) were capable of halting or even reversing trends in deforestation and forest fragmentation. The park periphery exhibited the highest proportion of degraded forest and deforestation, showing the susceptibility of the areas located just within the park boundary to human impact from the villages outside the park, despite frequent monitoring by the well-staffed Department of National Parks. In contrast, the buffer forest and community forest user groups considered the rules determining forest access to be legitimate and were willing and active participants in monitoring the forests and sanctioning of offenders. Thus, these groups were successful in protecting forest cover, limiting forest fragmentation, and encouraging regrowth.

The use of satellite images to detect cover change/modification is interesting, the matching of land covers with management regimes is novel, and the classification and transition matrix is informative, but a causality test was not carried out. In addition, little information on forest area, stocking levels, and uses was given; and no attempt was made to look into variations of the incentives and constraints across different ownership types. In addition, the distributions of cover change and modification must have been shaped by histories of land use (where they were and how they differed) and by differences in the locations of these forests. There was not an in-depth examination of the history of land use changes. Yet, they noted that community forests were heavily used by local populations prior to the 1990s for grazing, extraction of timber, fuelwood, and non-timber forest products, leading to the creation of highly degraded forests in many instances. Following initiation of community forest activities, user groups largely managed their degraded forests by providing protection. Consequently, there was an increase in vegetation density (22 percent regrowth) in the community forests. Given the landscape had been degraded before being devolved, this finding is not surprising, and the relevance of different forests in different stages of human exploitation should be reflected. Larson et al. (2010) captured this point of choosing an appropriate baseline for comparison.

Larson et al. (2010) in ***New rights for forest-based communities? Understanding processes of forest tenure reform***, reported findings from more than 30 sites in 10 countries in Africa (Burkina Faso, Cameroon, and Ghana), Asia (India, Nepal, and the Philippines), and Latin America (Bolivia, Brazil, Guatemala, and Nicaragua), where changes in formal tenure rights for forest-based communities had recently occurred or were in process. The article drew on a Center for International Forestry Research (CIFOR)-Resource and Rights Initiative (RRI) project (2006-2008) that sought to understand reform processes, particularly the extent to which community rights had improved in terms of the origins, nature, and initial outcomes of this forest tenure reform. They found that although the tenure reforms are highly variable, taken as a whole, certain patterns emerge, particularly in relation to typical land or agrarian reforms. For example, they identified cases where rights were granted to collectives rather than individuals, whereas alienation rights, or the right to sell the land, were not granted. Rather than redistributing land, forest tenure reform most often involved formally recognizing the rights of people already occupying the land. Rights often included obligations to conserve forests, and in this regard, the state usually maintained an important management role. Reforms were aimed not only at livelihoods or development concerns (and sometimes land rights) but also at responding to indigenous communities' demands for ancestral rights.

In addition, the most obvious pattern in outcomes is that results were more often positive for forests in Asia, mixed in Africa, and resulted in no change in Latin America, as "…most of these forests (in Asia) were highly degraded when handed over to communities" (p. 86). Compared with the Asian cases, the forests in Latin America were in reasonably good condition when granted to communities. The Asian cases and tree-planting areas in Ghana demonstrated improvements, primarily because the starting condition of the forest was low and reforms specifically prioritized conservation or regeneration. Other cases, such as Pando, Bolivia, suggested that dependence on agro-extractive activities generated an economic incentive to conserve the forest, while indigenous communities in Nicaragua and the communities in the Guatemalan highlands had little previous experience with forest conversion. In contrast, the sites in Cameroon and Burkina Faso appeared to be subject to more complex dynamics vis-à-vis elite capture and the clash between customary and statutory systems. It seemed likely that secure tenure alone in these vulnerable areas—places where livelihoods depend on agriculture, and population growth rates and colonization pressures were high—would have been insufficient to spur improvements in forest condition.

Larson et al. also elaborated on the distinction between *de jure* and *de facto* rights. Tenure reform may lead to some kind of *de jure* change that presumably favors communities. A *de jure* right concerns a set of rules established and protected by the state (e.g., registered land titles, concession contracts, the forestry law and regulations). In most cases, communities lived previously in the same areas and thus held *de facto* rights established outside the formal realm of law. These included customary rights, which constitute a set of codified community rules and regulations but may not be recognized by the state (e.g., ancestral titles and historic use of a land area). Given these previous rights, it should not be assumed that formalizing them would necessarily benefit communities. This study carries some very interesting and recent observations, and the authors measured forest condition using three main indicators: changes in forest cover over time (discerned from digital maps or through interviews), changes in forest quality (e.g., specific plants or animals), and frequency of forest fires. Unfortunately, the analysis is just "an informed qualitative assessment," as "it was impossible to obtain comparable quantitative data…"

Property rights and deforestation in the Brazilian Amazon by Araujo et al. (2009), was predicated on Deacon (1999), Southgate et al. (1991), and Lopez (1996). Deacon, working on a cross-country dataset, derived evidence of a detrimental effect of insecure ownership on deforestation. Using regional data, Southgate et al. demonstrated that deforestation in Ecuador was lower where land claims were more secure, as reflected in the relatively greater likelihood for farmers to have formal tenure. Lopez assessed the mixed efficacy of community control of forest management in Ghana.

Observing that insecure property rights resulted in violent land conflicts and expropriation procedures, Araujo and others proposed to use variables of land conflicts and expropriation processes to measure land property rights insecurity—a latent variable. Then, in their econometric analysis, they included the usual

determinants of deforestation (such as income, road, and population density) and a measure of land property rights insecurity. Dataset heterogeneity and a potential endogeneity bias of the insecure property rights measure were taken into account. With annual observations in nine states over 1988-2000, it was found that insecure property rights in land drove deforestation (by area) in the Brazilian Amazon; the elasticity evaluated at median values of insecurity and deforestation shows that a 10 percent decrease in insecurity induces a 7 percent decrease in annual deforestation rates. The idea of using certain observables to reflect insecurity, which is latent,[5] is innovative; the use of state-level annual deforestation data (derived from satellite images) and the consideration of endogeneity are steps in the right direction. Still, the measured insecurity deserves more attention, and it remains unclear how to reduce the insecurity of property rights along the huge frontier of migration and colonization effectively.

While many scholars have emphasized the concept of tenure security, its definition is often not clear or consistent. To further the understanding of economic behavior, Arnot et al. (2011) argued that the content and assurance aspects of tenures should be differentiated and measured separately. They posited that assurance aspects and their impacts on expected benefit streams have the most substantial impact on tenure security. However, the measures of content and assurance may well be correlated. For instance, two content measures are commonly used as proxies for tenure security—legal title and duration of tenure, which may be depicted with a single or multiple variables. Studies along this line suggest that there may be a reciprocal causality between tenure security and investment and assume that increased security of property rights will lead to decreased deforestation. Likewise, most papers using measures of the assurance of rights found negative correlations between security and deforestation, whereas those using measures of the content of rights found mostly insignificant impacts on deforestation.

Below are a few more regional-level studies that have investigated devolution from central to local governments and from government to private control. Pacheco (2000), Ribot (2001), Larson (2002), and Gibson and Lehoucq (2003) presented some of the preliminary studies. Pacheco argued that the mixed performance of municipal forest governance was principally related to the variable conditions with regard to finances and institutional capacity. This raised the inevitable question: If the financial pay-offs for municipal governments were the same regardless of whether they provide services or not, why did some actually provide services in the forestry sector? To overcome motivation problems, Ribot examined the usefulness of accountability mechanisms. That is, if municipal government officials were held accountable by their electorate and if the electorate demanded municipal administrations provide forestry-related services, such demands—if perceived by the local politicians—acted as an incentive to take political action.

In analyzing the performance of 21 municipal governments in Nicaragua that offer some services in the forestry sector, Larson paid particular attention to the underlying conditions that allowed some municipal governments to perform better than others. She found three key factors that help local governments become good resource managers: "capacity, incentive and interest" (p. 17). Gibson and Lehoucq interviewed 100 mayors in Guatemala to identify the factors that affected their attitudes and decision making regarding forest monitoring. They observed that "explaining the success or failure of decentralized environmental policies demands an understanding of the incentives and constraints that local politicians face" (p. 4). By comparing the influence of an array of variables, they showed that two—central government funding and the presence of local organizations in the forest sector—best explained the variations in the mayors' priority ranking of forest monitoring.

In ***Decentralized governance and environmental change: local institutional moderation of deforestation in Bolivia***, Andersson and Gibson (2007) noted: "[the d]ifficulty in using biophysical indicators to evaluate the performance of decentralized regimes is to isolate their effect from other policies that may have also affected, or even overwhelmed, that effect. The observed results are not necessarily explained by the decentralized governance *per se,* but more likely by a combination of factors" (p. 101). So,

[5] Persha et al. (2010) also used this method to derive a livelihood index based on reported dependence rates of various subsistence and commercial forest products.

they posited that varying forest conditions depend on the moderating effects that local institutions have on the socioeconomic and biophysical drivers of environmental change.

In analyzing data from interviews and remotely sensed images from 30 municipalities in the Bolivian lowlands, their model postulated that deforestation was determined by local institutions (summation of indices of property right facilitation, field presence, and technical capability), national policy (percentage of land use policy-defined agricultural areas), government monitoring (number of visitations per year by government officials), socioeconomic context (percentage of the population in each municipality that depends on firewood as its primary source of energy), and biophysical context (deforestation rate before 1993, road density, population growth, etc.). The key finding was that the local institutional performance affected unauthorized deforestation but had no effects on either permitted or total deforestation. The estimation of a regression model and the detection of regional deforestation using satellite images are laudable. The use of an instrumental variable for central monitoring is also interesting. Still, some independent variables were not well defined or enumerated, the sample was small, and the model design was problematic.

In ***Decentralization and deforestation: comparing local forest governance regimes in Latin America***, Andersson et al. (2010) observed that positive outcomes in decentralized governance: (1) were unlikely in the absence of popular participation in local government decision making; (2) relied on local governments being downwardly accountable to resource users and the technical capacity of the local unit to which responsibilities have been devolved; and (3) required a secure source of government funding. The key point in their reasoning was that the configuration of local institutional arrangements shaped the extent to which decentralization affected the environment. "A municipality that organizes itself to raise its own revenue is less dependent on external sources and thus enjoys more autonomy. This we see as an important proxy for local institutional capacity." They hypothesized that strong local governance arrangements—as evidenced by local capacity for generating local tax revenues—generated positive incentives for protecting local collective goods, such as forest resources.

The authors thus undertook a comparative analysis of a "longitudinal dataset" on environmental decision making from 300 local governments located in three countries with varying degrees of formal decentralization: Bolivia (limited), Guatemala (extensive), and Peru (no decentralization). Lagged forest cover data (%) at two points of time (2000 and 2006) derived from satellite images were used as the dependent variable. Included in independent variables were *de facto* decentralization (ranking of the importance of local revenues by respondents); *de jure* decentralization (whether the municipality was in a formally decentralized regime in forestry.

These studies showed that municipalities with more financial autonomy experienced less forest loss and invested relatively more in forestry activities. Another finding was that *de jure* decentralization seemed to have a very different effect on forest outcomes compared to *de facto* decentralization: the former appeared to have an inconsistent effect on outcomes (and the significance of the *de jure* variable is less robust). The study presents an encouraging use of forest cover data derived from satellite images. Given the actual observations (375) and municipalities (217) in their work, however, the conclusions are not really based on longitudinal data. While it may seem reasonable to include local financial capacity in their model, it is far from a sound indicator of governance strength. Several variables, noted above, relied on survey information, which may not act as ideal proxies. In addition, time lag and the feedback effect were ignored.

While less noticed, ***Impacts of rural reforms: the case of the Chinese forest sector***, authored by Yin and Newman (1997), represents an early and interesting study. According to the authors, China's rural forest sector responded to reforms differently, as reflected in the regional variations in their implementation. Both the south (a traditional forest region) and the north (a food basket of the country) experienced increases in the share of private tenure on their forest lands and witnessed improving market incentives, but authorities were slower to liberalize and quick to rescind some of the reforms in the south. As a result, an uncertain policy setting was created that might explain its poorer performance. For instance, Jiangxi, a province in the south, saw a slight expansion of its forest area (from 5.47 to 5.90 million ha) but a large decrease of its

stocking volume (from 298.6 to 242.1 million m^3) during 1977-1987. Meanwhile, Henan, a province in the north, witnessed a major gain in stocking volume (from 68.2 to 91.5 million m^3) due to various agroforestry activities, even though its forest area did not experience a commensurate increase.

The authors asserted that these contrasting experiences demonstrated the critical importance of investor expectations and stable policy environments for long-term investments. An econometric analysis was then conducted by regressing production responses, through changing timber harvest, stocking volume, and forest area, against the major policy instruments (the percentage of devolved forestland under the household responsibility system [HRS] and price liberalization) and other factors. Panel data came from four prefectures in the north and five in the south, covering the 1978–1989 period. All dependent variables in the north witnessed an increasing trend, while both harvests and inventory in the south suffered a decline. In both regions, timber harvests responded positively to the adoption of the HRS. However, the coefficient in the south was highly significant, whereas in the north it was insignificant. Stocking volume and forest area in the north also responded in a significantly positive way to the introduction of the household responsibility system. On the other hand, they were both negatively associated with the HRS in the south, though insignificantly. As to the effect of price reform, farmers' responses in the south were insignificant, whereas they were significantly positive in the north. This regional-level, comparative study included forest area and volume derived from inventory information, which is rare. It is also informative to account for responses in multiple dimensions and variations in regional conditions. The period of the data (12 years) seems short, and it would be more convincing if a micro-level profile of the reform implementation and forest condition were added.

In a follow-up paper, Yin and Hyde (2000) assessed the effect of trees as an agricultural productivity-enhancing activity in northern China. They argued that the nearly complete removal of forest cover from China's northern plains before the renewal of household incentives and subsequent reforestation in the late 1970s provided an unusual broad-scale opportunity to examine the impact of forest-based environmental services on long-term agricultural productivity. They tested that proposition using an agricultural production function with a measure of forest cover as a production shifter. Their evidence from Shandong Province showed that agroforestry activities rapidly produced approximately 10 percent increases in agricultural productivity.

4.0 SELECTED CASE STUDIES

As noted in the beginning of this paper, in addition to these more rigorous empirical analyses summarized in the last two sections, a large number of case studies have tackled the linkages between devolved tenure systems and forest conditions. Here we discuss some selected studies, based on their relevance to Latin America, Asia, and Africa. We list these studies in Table 3 of Annex A to show that there have been many studies on this this tenure – forest condition interface from Latin America, but fewer from Africa. While the number of studies from Asia abound, they are concentrated on South and Southeast Asia. Furthermore, as remarked by Blomley (2013) on the basis of Africa's experiences, the literature on many CBFM cases has some common characteristics. Much of it iswritten by project proponents involved directly in the planning and execution of community forestry initiatives, such as NGOs or donors. As such, it may lack an independent or critical eye. In addition, the case studies are often site or project specific, with little effort to extrapolate findings to landscape, national, or regional scales. Finally, the focus is on "snapshot" assessments, as there are few quantitative assessments of change from established baselines.

LATIN AMERICAN CASES

In ***Development policies and tropical deforestation in the southern Yucatan Peninsula: centralized and decentralized approaches***, Klepeis (2003) used the case of the southern Yucatan Peninsula to illustrate the need for historical analysis in identifying key drivers of deforestation. According to him, the most important land use changes in the region over the past 100 years are connected to shifts in national development policies. These shifts represent tensions between centralized and decentralized approaches to land management—as reflected by the policies of Presidents Diaz (1876-1910) and Cardenas (1934-1940). The legacies of these recurring development strategies include depleted hardwood reserves; large areas of permanently cleared forest; and long-standing tensions between economic, social welfare, and environmental conservation goals. While centralized and decentralized approaches both focused on natural resource exploitation, the rates of deforestation tended to be faster, the patterns of forest clearing more pronounced, and land use decision making less democratic under systems of centralized control. As profound as these observations may be, the evidence presented was not particularly robust or compelling.

In ***Property rights, land conflicts and deforestation in the eastern Amazon***, de Oliveira (2008) demonstrated that insecure property rights are among the main causes of land conflicts and deforestation. Through an in-depth case in Maranhao in the Eastern Amazon, he analyzed how distorted agrarian, forest, and environmental policies, laws and regulations led to insecure property rights not only over land, but over timber. These policies, allied to social and political factors—such as uneven distribution of land and the strong organization of the landless—led to land conflicts and deforestation. He also elucidated that the causes of and actors involved in the deforestation of the Amazon were not interrelated. The policy distortions fostered an environment of insecure property rights whose adverse consequences included a lack of incentives for private investments in land improvements, rent dissipation in organizing invasions (in the case of the landless) and in protecting properties against invasion (in the case of the landowners), violent social unrest in some cases, and ultimately, uncontrolled deforestation and land degradation. Hence, this study found that coordination between environmental goals and agrarian policies, regulations, and laws are necessary to provide secure and clear property rights, which may allow better enforcement of environmental regulations and may provide incentives to actors to avoid deforestation.

In ***Explaining community-level forest outcomes: salience, scarcity, and rules in eastern Guatemala***, Gibson et al. (2007) began with Ostrom's earlier notion that the attributes of the natural resource and of the appropriators of that resource that might affect the likelihood of whether or not an individual would choose to invest time in a collective solution. Then, they pointed out that two of the attributes are more than just

additional influences on individuals' cost-benefit calculations; rather, they are necessary to motivate—communities do not create restrictive institutions concerning a resource unless: (1) the community members depend significantly on the resource, and (2) there is a perceived scarcity of the resource. The second of these two conditions did not apply to the Morán case, and as a result, their forest was open to all members to use. In comparison, the two conditions did hold for agricultural land in the area, and a number of locally constructed restrictive institutions guide the management and exchange of this valuable resource. Based on the IFRI data, their tests (in which pine diameter at breast height [DBH] was a function of stand density, elevation, steepness, insects, distance to settlement, distance to road; and stand density is a function of elevation, steepness, insects, distance to settlement, distance to road) detected that biological and physical variables explain most of the variation, with little left to institutional effect.[6] Their results are appealing and offer a strong warning to those institutional scholars who ignore the effects of biophysical and socioeconomic factors.

In ***Land tenure and forest cover change: the case of southwestern Beni, Bolivian Amazon, 1986-2009***, Paneque-Gálvez et al. (2013) assessed whether significant differences in trends of forest cover change could be partially explained by different land tenure arrangements. They examined spatiotemporal dynamics of forest cover change across four land tenure systems (indigenous titled territory, PA, logging concession, and private land) by classifying forests using Landsat imagery from four years (1986, 1996, 2001, and 2009). The results showed that (1) private lands underwent, by far, the largest forest cover change; (2) indigenous territories and the PA had little forest cover change; and (3) logging concessions were responsible for the lowest forest cover change. These findings implied that land tenure played a key role in forest cover change except in private areas, where many other drivers had operated. It is encouraging that this study discriminated between early growth and old-growth forests, which is crucial to address not only deforestation but also forest degradation and regrowth. However, the qualitative analysis of the impact of each driver on forest cover change within the five study areas was not particularly strong.

In ***Inhibition of Amazon deforestation and fire by parks and indigenous lands***, Nepstad and colleagues (2006) used satellite-based maps of land cover and fire occurrence to compare the performance of large (>10,000 ha) uninhabited (parks) and inhabited (indigenous lands, extractive reserves, and national forests) reserves in the Brazilian Amazon. Reserves had significantly lower deforestation and fire impacts. Deforestation was 1.7 (extractive reserves) to 20 (parks) times higher along the outside vs. inside of the reserve perimeters, and fire occurrence was 4 (indigenous lands) to 9 (national forests) times higher. However, uninhabited reserves tended to be located away from areas of high deforestation and burning rates. In contrast, indigenous lands were often created in response to frontier shift, and many acted to prevent deforestation despite high rates of forest loss along their boundaries. The inhibitory effect of indigenous lands on deforestation was strong after centuries of contact with the national society and was not correlated with indigenous population density. Indigenous lands occupy one-fifth of the Brazilian Amazon—five times the area under protection in parks—and are currently the most important barrier to deforestation in the Amazon. Thus, as the PA network expands in the Brazilian Amazon over the coming years, the greatest challenge will be successful implementation of reserves in high-risk areas of frontier expansion as indigenous lands rights are strengthened.

ASIAN CASES

In ***Lowland forest loss in protected areas of Indonesian Borneo***, Curran et al. (2004) found, using satellite imagery, that during 1985-2001, the study area lost 56 percent of its forest cover due mostly to logging and oil palm plantations. They attributed the accelerated deforestation rates to decentralization reform and described how the reform allowed local governments (districts) to issue small logging permits that caused the "unauthorized harvest of remaining accessible lowlands" (p. 1002). Similarly, McCarthy (2004)

[6] Similar empirical results were contributed by Coleman (2009), who found that average forests with local users that monitor and sanction are more likely to sustain basal area and biodiversity.

revealed that in Central Kalimantan of Indonesia, decentralization produced a race to the bottom in the forest sector due to ambiguity in the rights and rules over forests, which have shortened actors' time horizons and led them to a "race to make the most of current opportunities without regard to future operations" (p. 1215). Tacconi (2006) also illustrated that in Indonesia, the period in which decentralization was introduced coincided with a significant deterioration of the rule of the law, a trend that started during the final years of the Suharto regime. Palmer and Engel (2007) quantified the impacts of mechanized logging on forest-dependent communities in Indonesia. They suggested that significantly more households received financial and in-kind benefits after decentralization compared to before, and little evidence existed of a post-decentralization trade-off between environmental and financial contractual provisions. In this case, weak implementation of decentralization and a decline in rule of law associated with new and ambiguous rights led to an overall decrease in forest condition, as rights were devolved.

In ***Landscapes of protection: forest change and fragmentation in Northern West Bengal, India***, Nagendra et al. (2008) attempted to relate different tenure arrangements to forest change and fragmentation between 1990 and 2000 in a landscape surrounding the Mahananda Wildlife Sanctuary in West Bengal. This protected forest was bounded to the south by the Baikunthapur Reserve Forest (a less intensively managed PA), and surrounded by a mosaic of unprotected, largely private land holdings. Their results indicated differences in the extent and spatial pattern of forest cover change in these three zones, corresponding to different levels of government protection, access, and monitoring. The two PAs experienced a trend toward forest regrowth, relating to the cessation of commercial logging by park management during this period. Yet, there was still substantial clearing toward the peripheral areas connected to illegal timber markets by transportation networks. The surrounding landscape, although witnessing forest regrowth within less intensively cultivated tea plantations, also became increasingly fragmented, with critical impacts on the maintenance of effective wildlife corridors in this ecologically critical region. This study underscores the importance of different management regimes within a given tenure system that may be of utmost importance in forest condition outcomes.

Two other recent studies in the Indian Himalayas have carefully addressed the issue of institutional change and forest conservation. In ***Forests to the people: decentralization and forest degradation in the Indian Himalayas***, Baland et al. (2010) used physical measurements taken from 399 forests patches (83 villages) in Uttaranchal (now Uttarakhand) to examine indicators of forest health. They controlled for factors that may affect forest use and differing uses of neighboring forests to isolate the impact of community management (Van Panchayats) on forests. They found that lopping of branches was 20-30 percent lower in CBFM forests compared to state-protected and open access forests. However, other measures of forest quality (e.g., cover density and timber volume) were not as favorable in CBFM areas. Thus, the authors concluded that CBFM was successful in achieving certain biophysical outcomes, specifically firewood and fodder extraction by locals but not tree-cutting, timber extraction, forest grazing, or encroachment.

In ***Decentralization for cost-effective conservation***, Somanathan et al. (2009) used satellite data to examine crown cover in forest patches under CBFM and state forests in Uttarakhand. After controlling for confounding factors, they found that community forests were no more degraded than the state forests, suggesting that these communities were able to manage forests at least as well as the state forest department. The authors went on to demonstrate that under these conditions in India, it was much more cost-effective for communities to manage forests.

AFRICAN CASES

In ***Community-based monitoring of natural resource use and forest quality in montane forests and miombo woodlands of Tanzania***, Topp-Jørgensen et al. (2005) argued that a key element of the new Tanzanian Forest Policy and Forest Act was the devolution of ownership and management responsibilities over forest resources to local communities. Local communities were given an opportunity to obtain lease rights over government forest reserves through joint forest management (JFM) agreements or the ownership of forest resources through CBFM agreements. A community-based monitoring system focusing on forest

use and quality in montane evergreen forest and Miombo woodland areas was introduced in 23 villages in 2002 in Iringa District. The monitoring scheme provided communities with the relevant information needed to suggest appropriate management interventions. However, opportunities to provide economic incentives for montane forest managers through direct utilization of the resource were limited, and it was unclear whether other non-economic incentives could sustain long-term community commitment in these biodiversity-rich areas. The author implied that the key elements of this local monitoring scheme were simplicity, incentive mechanisms, transparency and accountability, and autonomy for local managers.

Later, in ***Seeing the wood for the trees: an assessment of the impact of participatory forest management on forest condition in Tanzania***, Blomley et al. (2008) developed three cases to demonstrate that participatory forest management (PFM) appeared to be contributing to sustainable forest management. The first case study measured temporal changes in forest condition under participatory and non-participatory forest management. Data were gathered from 13 forests over 1997-2007 in five regions across eastern, central, and northern Tanzania. The results showed an increase in basal area and volume of trees per hectare over time in Miombo woodland and coastal forest habitats under PFM and JFM, whereas these measures in similar forests under state or open access management declined. The second study involved three matched pairs of JFM vs. non-JFM in Morogoro Rural and Kibaha Districts using retroactive experimental design. The results indicated that coastal forest and sub-montane Eastern Arc forests under JFM had higher numbers of live and naturally dead trees, poles or withies, and fewer cut timber trees, compared with forests managed exclusively by the state, and greater mean height and tree diameter. The third case was a spatial comparison of JFM vs. non-JFM forests from 477 km of sample transects, which revealed declining levels of cutting in coastal forest and Eastern Arc forests over time. However, a statistical regression analysis showed that time since implementation of JFM was not statistically significant. As a result, they suggested that Tanzania could provide a good case study because of the long history of community forest management and well-developed system of village governance under elected councils and assemblies.

In ***Profiling local-level outcomes of environmental decentralizations: the case of Cameroon's forests in the Congo Basin***, Oyono (2005) noted that starting in the mid-1990s, Cameroon launched a process of decentralizing the management of its forests by transferring powers over forests and financial benefits to local communities. This article showed that the experiment has not yet led to the expected positive resource outcomes and very often generated internal conflicts, a new social stratification, and the marginalization of traditional authorities. Second, the devolved management did not produce positive economic results, as there was no significant economic change in the case study villages. Third, the experiment led to negative environmental results, such as the degradation of many community forests. As such, the author recommended that policymakers, NGOs, and the local communities should collaborate in the design of a monitoring framework for decentralized management, underscoring the need to invest in institutional development alongside devolution efforts.

In **PFM in Oromia and SNNP regions of Ethiopia: A review of experiences, constraints and implications for forest policy**, Jirane et al. (2007) reviewed lessons learned and impacts of PFM to date in nine Ethiopian forests and concluded that forest management outcomes had improved under JFM—including increased forest regeneration and decreased levels of disturbance and illegal harvesting. Winberg (2010) reviewed outcomes from PFM across 24 JFM sites in Ethiopia and determined that disturbance levels were lower and natural regeneration higher in JFM forests than in state-managed ones.

In reviewing the recent empirical studies on the outcomes of popular participation in forest management in sub-Saharan Africa, Ribot et al. (2010) described that although promises of improvements in relation to forest management, rural livelihoods, and local enfranchisement have been achieved in some cases, accounts of frustration outnumbered those of success. They explained that the expected benefits of democratic decentralization within forestry were seldom realized because democratic decentralization had rarely been established. In most cases, local government authorities did not represent the local population, or their space of discretion was so narrow that they had little effect on management. There was little local management, even under so-called decentralized or participatory arrangements. Three observations were made on the

effects of decentralization: (1) environmental, livelihood, and democracy objectives were not always mutually reinforcing, and under some circumstances they were at odds; (2) the environmental effects of improved forest management often resulted in benefits accruing to distant or higher-scale aggregate populations, while local communities bore the costs; and (3) poor peoples' use of natural resources to maintain their livelihoods often conflicted with the profit and revenue interests of localities, national commercial interests, and governments.

META ANALYSES OF CASE STUDIES

Notably, a significant stream of the literature enters into the debate about the conservation effectiveness of PAs by comparing protection regimes with other tenure regimes, including CBFM. Numerous studies address the question of whether the tenure regimes of PAs are more successful in conserving forests than non-PAs, some of which have been cited earlier (e.g., Hayes, 2006; Persha et al., 2010). Here, we discuss a few meta-analyses of the published case studies. The basic message coming from these studies is that communities can be good forest managers in some cases, but community management or other devolved regimes are not a panacea for obtaining improvements in forest conditions.

An exhaustive search of the peer-reviewed literature of case studies enabled Porter-Bolland et al. (2012) to identify 40 Protected Areas (PA) and 33 forests under community-based management (CBM). They then estimated that the mean annual rate of forest cover change in PAs was -1.47, indicating a net loss of forest cover. There was, however, a wide variation in the data (standard deviation = 3.46) with a max annual rate of deforestation of -19.40, and a max rate of forest recovery of 0.40. In contrast, for the CBM cases, the mean rate of forest cover change was smaller than for PAs (-0.24). Maintenance of forest cover or its recovery occurred in 47.5 percent of PA cases and in 60.6 percent of CBM cases. As a whole, community-managed forests presented lower and less variable annual deforestation rates than PAs. These findings seem to support their hypothesis that community-managed forests may be at least as, if not more, effective in reducing deforestation as PAs at the pan-tropical scale. As such, they asserted that tropical forest PAs may not always represent the best way to conserve forests vis-à-vis tropical forests locally managed for production of goods and services.

Nonetheless, at the end they acknowledged the possibility that forests under CBM in their sample show lower deforestation rates than PAs as a function of historical patterns in forest cover change across space and time. For instance, PAs may show higher annual rates of deforestation because they could have been established where threat of forest conversion to other uses were high. Forests under CBM may show lower deforestation rates because they could have been allocated under specific circumstances where either the threat or the perceived consequences of deforestation were deemed not as serious. This is a point of emphasis. As indicated by Larson et al. (2010), the tenure regime itself is not necessarily the most important factor in forest cover change; other reasons include the poor starting condition of the forest, economic incentives for conservation, and/or the remoteness of the area. Bowler et al. (2010) provided another meta-analysis of 42 peer-reviewed articles that came to a similar conclusion, finding that CBM was associated with greater tree density and basal area but not with other indicators of global environmental benefits (e.g., biodiversity).

Casse and Milhøj (2011) is yet another meta-study of local forest management experiences in developing countries drawn from 56 case studies presented in 52 papers. They began with a few astute observations: (1) many case studies report positive links between community forestry and forest conservation; and (2) international organizations and NGOs generally agree that community forestry will yield success in forest conservation; but (3) the claim is seldom rigorously examined. They proposed to test the claim by reviewing the literature to reach an initial generalization as to the success of CBFM in forest conservation. Their test uncovered no systematic correlations (negative or positive) between presence of CBFM and forest conservation, whether defined as lowering deforestation rates or increasing biomass and improving perceived forest condition. Further, the reviewed papers were heterogeneous in their approaches, and the authors suggested that the state still has a role to play, even when the transfer of forest management rights to local communities is genuine.

Similarly, Nagendra et al. (2009) did not find that high deforestation rates were more prominent for PAs as compared to community-managed forests. Using a metadata analysis of information on 49 locations from 22 countries, the author evaluated the impact of PAs on land cover clearing and found that PAs had significantly lower rates of clearing in comparison to their surroundings. In addition, PAs had significantly lower rates of clearing within their boundary following initiation of protection. Thus, PAs did appear to be effective in limiting overall land cover clearing. There was some variation in the rates of clearing across regions, where most PAs in North America and Europe showed positive rates of forest cover change, while PAs in Asia had the highest rates of land cover clearing. While most PAs in North America and Europe involved a relatively smaller number of actors, a greater number of deforestation actors and drivers of clearing were implicated in PAs in Asia, Africa, and Latin America, indicating the increased difficulties faced by park management in these regions.

Robinson et al. (2011) further reviewed the literature that connects forest cover change and land tenure to understand the broad interactions between tenure regimes (including protected areas, general public land, private land etc.), tenure security, and forest change. They obtained 36 publications that link forest cover change to tenure conditions while also controlling for other plausibly confounding variables. Since publications often investigate more than one site and more than one form of tenure, they were able to derive 118 cases linking forest change with a specific tenure form in a particular location. From these, they found evidence that PAs were associated with positive forest outcomes and that land tenure security was associated with less deforestation, regardless of the form of tenure. Given the wide regional variability, the authors reminded the readers that public frontier land is generally more associated with negative forest outcomes and that PAs had slightly more positive than negative forest cover change. Hence, they called for more robust identification of this relationship in future research.

COUNTRY EXPERIENCES OF DEVOLUTION

Having discussed the primary literature and case studies, the following section presents the experiences of seven countries—CBFM in Nepal, JFM in India, forest control transitioning from collectives to individuals in China, devolved rural tree tenure in Niger and Tanzania, social forestry in Mexico, and engagement of indigenous and local people in forest management Brazil—to document the diversity of devolution processes on tenure and property rights systems and the subsequent ecological outcomes. This highlights the following conclusions. First, devolving the control of forests goes way beyond promoting CBFM; it encompasses granting the control, management, and use of forests to local private as well as public entities. Thus, a variety of forms of devolution should be considered. Second, by offering more detail of the processes and outcomes and reflecting on the progress made and challenges encountered across these different forms of devolution, the opportunity will emerge to develop a coherent, comparative perspective of international experiences and thus better identify what actions need to be taken and how they can be properly implemented.

Echoing White and Martin (2002), Chomitz et al. (2007) noted that communities are increasingly sharing management or taking ownership of public forests. In principle, communities should be better than distant government agencies at managing and policing their forests and better suited than individuals to exploit economies of scale in forest management. However, successful CBFM depends on the strength of community organization, the regulations facing communities, and economic and cultural incentives to maintain forests. Communities also need strong social capital to enforce compliance with management rules and avoid elite capture of forest resources.

Devolving forest control in Nepal began in the late 1970s.[7] The precursors of the current community forestry legislation were the Panchayat Forest Rules of 1978 and the Community Forestry Program of 1980. The framework for community forestry legislation is represented by the Master Plan for the Forestry Sector in 1989, the Forest Act in 1993, and the new Forest Regulations of 1995. This legislation accelerated the pace

[7] This background narrative is based on Agrawal and Ostrom (2001, pp. 498-500) and Nagendra (2007, p. 15219).

of change, leading to a tremendous increase in the area of forests managed by local user groups and the number of these groups. User groups can use their forests for subsistence, cultivating non-timber forest products, growing trees, and harvesting forest products for commercial purposes, but they are not permitted to clear the forest for agricultural use. While the generated cash revenues are not taxed, user groups are required to spend 25 percent of all cash income on collective development activities.

By 1999, 8,500 community forest user groups (CFUGs) were formed, consisting of nearly one million households managing over 6,200 km^2 of forests—about 10 percent of the total forest area of Nepal. Since then, new user groups have continued emerging, as has a nationwide federation of community user groups. According to Kanel (2008), there are currently 14,572 CFUGs scattered throughout Nepal covering a total area of 1.2 million ha (25 percent) of the forestland. Some areas in the middle hills have seen a slow reversal of earlier deforestation and forest degradation. Thus, Nepal is often seen as a frontrunner among developing countries in creating progressive programs and legislation related to resource management and conservation.

India's Joint Forest Management program is also well known. Although there were precursors, nationwide adoption of the program grew out of the National Forest Policy of 1988. By 2005, JFM covered 27 percent of the national forest area across 27 states (17.3 million ha) and included more than eight million families—half belonging to scheduled tribes and castes (Chomitz et al., 2007). Although program rules differ by state, they give communities access to forests for fuelwood, fodder, and other extractive products and grant them a small proportion of revenue from commercial timber sales. More degraded, less commercially valuable forests are the most likely to be put under the program. A nuanced comparison of forest devolution schemes in Nepal and India by Agrawal and Ostrom (2001) revealed that although the CBFM program in Nepal is relatively recent in origin, the formal aspects of the program—and many effective examples of its operation—involve substantial levels of decentralization. JFM in India has widely variable outcomes; but, overall, the forest department continues to exercise significant managerial control over local actors. Unlike the CBFM case in Nepal, participants in JFM have little control over how commercial products, such as timber, are sold and how the proceeds allocated.

Regardless of their similarities and differences, Nepal's CBFM and India's JFM have attracted broad attention from academic and development circles. For example, Schweik et al. (2003) claimed that Nepal's CBFM explained the persistence of forests in areas that would otherwise be under deforestation pressure. Examining the Nepalese experience over 1976-2000, Gautam et al. (2004) found that the highest net gain in forest cover came in semi-government forests – areas legally under the forest department but often with *de facto* control and even ownership claims by communities. These were followed by formalized community forests (including leasehold), with government-run forests faring least well. Likewise, one early review found that JFM has enhanced forest regeneration (Murali et al., 2002), and studies suggested that JFM has made a positive impact on livelihoods (e.g., Sarin et al., 1998; Shyamsundar and Bandyopadhyay, 2004). However, Malla (2000) indicated that after implementing community forestry, poor Nepalese lost their privileged access to forest products, such as fuelwood, because under new rules, the user groups shared those products equally among all households. Also, central governments in both countries used various strategies to obstruct the devolution of forest management and, hence, retain central control (Agrawal and Ribot 2006).

Later, IFRI sample sites in both Nepal and India have been heavily featured in several major studies, such as Chhatre and Agrawal (2008, 34 and 51 out of the 152 forest commons from India and Nepal respectively); Chhatre and Agrawal (2009, 45 from South Asia, including India and Nepal, as well as Bhutan, out of the 80 cases); and Persha et al. (2011), 27 and 25 out of the 84 cases from India and Nepal, respectively). As cited earlier, Nagendra (2008) asserted that community-based institutions, including participatory management programs in the park buffer and the designated community forests in the Terai Valley of Nepal's Chitwan District, are capable of halting or even reversing trends in deforestation and forest fragmentation.[8]

[8] As a matter of fact, this result was already primed in her earlier work (Nagendra, 2007), which analyzed the associations of perceived changes of forest cover with tenure regimes, local monitoring and forest size of 55 sample sites (see Section 3 for more detail). Again, it should be clarified that "park" means PA.

Meanwhile, the park periphery exhibited the highest proportion of degraded forest and deforestation. It is the assessed outcomes of these and other works that prompted Ostrom and Nagendra (2006) and Ostrom (2010) to declare that it is becoming clearer that community management, under direct ownership, government concessions, or other long-term co-management arrangements, has the capacity to be as effective or, under certain conditions, more effective than publically managed PAs. Moreover, debate over the effectiveness of PAs needs to be extended to a much larger landscape of tenure regimes that include various forms of co-management, in which local communities have substantial management responsibilities and access to resources in and around a park and a wide variety of community management types.

Certainly, the Nepal and India cases are encouraging, representing pioneering work in promoting and practicing CBFM and JFM, and the remarkable analytic results derived, wholly or partially, from IFRI's study sites in these countries are impressive. At the same time, certain cautions should be heeded. First, if the forests in the middle hills (or other places) were degraded before being devolved to communities, whereas those in the PA of the Terai Valley (or elsewhere) and its buffer zone were undisturbed, then the two types of forests have had distinct paths of evolution, having been shaped by different historic legacies of human pressure and access. As described by Larson et al. (2010), most of the forests had been degraded before being handed over to communities, implying a distinct legacy compared to other forests, including those in PAs. This point has profound implications for properly selecting baselines for comparing forest condition change and/or isolating the effects of different tenure regimes on change. By comparing remote sensing data between 1990 and 2000, Nagendra (2010) documented multiple examples of both PAs and community user groups that are able to stem deforestation and degradation under certain circumstances such as resource scarcity and stricter protection in Nepal and India.

China's transition of forest control from collectives to individuals provides relevant insights. This is because while China's initiatives and experience have been more far-reaching, they are less examined by and known to the international community. As noted by Hyde et al. (2003), while tenure reforms in other countries delegate forest control from a centralized entity to local ones, China delegates both responsibility for and benefits from forestry directly to individual operators—households. In many areas, the management and use rights of as much as 90 percent of formerly collectively controlled forestland has been devolved to individual or small groups of families in some egalitarian fashion while retaining nominal collective ownership (Xu, 2010). This process has been accompanied by signing legal contracts and issuing usufruct certificates, which differentiate the current wave of tenure reform from that of the 1980s. It has also expanded the households' tenure rights to include transferring, inheriting, and mortgaging forestland, in addition to access and management. Other major policy measures, such as relaxing the logging control and reducing taxes and fees imposed on timber sales, have been adopted as well.

Altogether, over 102 million ha of forestland were transferred to more than 72 million households (Yin et al., 2013). These are unprecedented changes in the developing world and represent fundamental moves toward a forest sector that is consistent with a market economy and sustainable forestry. Therefore, it appears the basic incentive structure and the prospects for vibrant forestry development have improved. The initial response, as shown in people's increased interest in and actions of tree planting, forest management, and/or timber harvesting, seems positive (Xu, 2010). Meanwhile, forest resources in the northern plains and "economic forests" and bamboo forests in many parts of the country have seen phenomenal growth over the last two decades. In contrast, there remain policy inconsistencies, conflicts, and even maladaptations mostly in the southern commercial forest region that, if not dealt with in a timely and effective fashion, can easily dampen any improvement in the incentive structure and outlook for future development (Yin et al., 2013).

The transformation of Niger's landscapes through "re-greening" efforts over the past 20 to 30 years is also noteworthy, despite its location in arid/semi-arid Sahel and increasing population pressure (WRI, 2008). This great change is not only "turning back the desert" and reversing deforestation that peaked in the 1970s via forest regrowth and vegetation restoration, but it has also brought other benefits. Included in these benefits are water table recharging and improved water availability; enhanced livelihoods through improved agricultural productivity; diversified incomes including wood, fodder sales, and more diverse cropping; and

enhanced resilience to climate fluctuations. The authors attributed this transformation to two factors: the adoption of simple, low-cost techniques for managing the natural regeneration of trees and shrubs (known as farmer-managed natural regeneration) and the use of simple soil and water conservation programs in many communities to drive the greening transformation in concert with forest management. In addition to the farmer-to-farmer communication and support from NGOs, this has been achieved through devolved rural tree tenure since 1993 and local ingenuity. According to Blomley (2013), commercially oriented production and harvesting of firewood and charcoal from dryland community forests in Niger and Burkina Faso has since spread to Chad, Guinea, Mali, and Senegal.

Tanzania is another African country with a wide CBFM and JFM spread. Blomley et al. (2008) reported that there were more than 1,800 villages engaged in CBFM and co-management, covering 3.6 million ha, or 10 percent of the total forest area of 34.6 million ha or roughly 23 percent of the 15.6 million ha that lie outside PAs on village and other lands. In a review of eight CBFM and JFM sites in Tanzania, Vyamana (2009) found CBFM sites were better managed with lower levels of disturbance than JFM sites. Following an investigation of six sites in the East Usambara Mountains of northeastern Tanzania covering a range of management regimes, Persha and Blomley (2009) detected that forest condition outcomes were best under community and traditional forest management regimes and worst under joint and state-managed regimes. However, Blomley (2013) pointed out that although the law allows for joint management of forest reserves by communities and government, the mechanism for sharing revenues and costs between each party has yet to be established in law in Tanzania. As a result, management agreements are often submitted for signature and then shelved by government civil servants who are unwilling to risk legalization in the absence of an adequate legal framework. Overall, a recent analysis by RRI estimates that almost 98 percent of forested land in Africa remains controlled or "administered" by national governments, while only 0.5 percent is formally "owned by communities or Indigenous Peoples" or "designated for use by communities and Indigenous Peoples." The remaining 1.6 percent is "owned by individuals or firms" (RRI, 2012).

Community forestry in Mexico[9] began in the 1980s in response to the government's efforts to liberalize the national economy and reduce the presence of the state in the forestry sector. The 1986 Forest Law—a turning point in Mexican history—abolished forestry concessions and recognized the rights of local communities organized in *ejidos* to manage their forest resources (Merino-Pérez and Segura-Warnholtz, 2005). According to a recent study, 2,300 communities—representing nearly 15 percent of those with significant forest commons—acquired permits to engage in commercial logging during the period 1992–2002; most of these only used 25 percent of their standing forests for harvesting and left the rest for other purposes (Bray et al., 2005). Community forestry has also contributed to the enactment of strict regulations to combat illegal logging, control fires and halt degradation and deforestation processes at community level (DiGiano et al., 2013). Barsimantov (2010) highlighted that shared economic interests in timber and other forest resources, combined with strong governance and shared ethnicity, are key explanatory factors of community conservation. However, the *ejidos* increasing control of forest resources during the last three decades has not translated into a significant decrease in deforestation rates (Corbera et al., 2011). From 1976–2000, Mexico was among the most deforested countries in the world, with average deforestation rates of 86,718 ha/year for temperate forests and 263,570 ha/year for tropical forests, while the total annual loss for all ecosystem types averaged 545,000 ha/year (Bray et al., 2005). In particular, *ejido* community lands that had become privatized into large units had higher rates of deforestation, while in some cases commonly held *ejidos* lands still controlled by the community exhibited lower deforestation rates (DiGiano et al., 2013).

Recognizing the territorial rights of traditional communities in Brazil is a recent development. Forest tenure in the Brazilian Amazon is divided between private (24 percent) and public lands (76 percent) (Corbera et al., 2011). The former include forests owned by individuals and organizations, and the latter include protected areas (40.3 percent), indigenous lands (21.7 percent), sustainable use areas (10.8 percent), exclusively protected areas (7.8 percent), land reform settlements (5.3 percent), and forests under dispute (30

[9] This overview of social forestry in Mexico and competing land claims in Brazil has heavily drawn from Corbera et al. (2011).

percent). The constitutional recognition of territorial rights of traditional communities and the continuing demarcation of indigenous lands suggest that social property exists, as a result of a growing acknowledgment of historical rights of occupation by traditional users within the public land ownership. Forest privatization in the Amazon may further expand in coming years as public lands at the frontier become subject to title regularization for small to medium informal land users who had occupied public lands in "good faith" (Corbera et al., 2011). Also, a 2007 law on public forest management allowed long-term forest concessions to be established within public lands to encourage long-term sustained yields through secure tenure and the oversight of a newly created Brazilian Forest Service.

By law, the state exercises strict control over community land accessed through agrarian reforms by enforcing land use plans, which are required as part of the transfer process. In some cases, legal reserves have been established as common management areas in such settlements but these reserves are often designated on individuals' own plots and subject to unrestricted use. Indigenous and riverine communities have greater autonomy but they also show mixed results regarding tenure conflict and sustainable resource management. As a result, Brazilian tenure regimes are affected by multiple claims and conflicts, illustrated by the large area of "forests under dispute" (Larson et al., 2008; Nepstad et al., 2006; Duchelle et al., 2014). Conflicts are common between timber extraction companies and local communities, as well as between local communities and cattle ranchers and between colonists and communities as the former aim to take control over indigenous or informally occupied lands at the frontier (de Oliveira, 2008; Sunderlin et al., 2014). It is thus not surprising that deforestation was heavy until recently (Hansen et al., 2013). Total regional deforestation is estimated to have reached nearly two million ha per year from 1996 to 2005. Ranching is responsible for more than 80 percent of the total, with the remainder due to a combination of recent soybean and other crop incursions and urban-industrial occupation, including road building and hydroelectric reservoirs (Corbera et al., 2011).

5.0 EXAMINING THE THEORETICAL AND EMPIRICAL ISSUES

SOME COMMON ANALYTICAL CHALLENGES

Regardless of the scale or orientation of research on the linkages between forest condition and devolved tenure, many of the reviewed studies have utilized the conceptual construct of the forest commons. Commons tend to feature some kind of local resource governance system around the collective use and management of a particular resource. While much has been learned from the theory and principles of governing the commons (Ostrom, 1990), moving beyond this perspective is warranted to deal with the more complex challenges encountered through devolution policies and legislation in many developing countries. Forest commons management regimes vary considerably. For example, the forest commons can be managed almost like a private entity by a group of individuals, a community organization, or a formal corporation to foster growth of forest productivity and ecosystem sustainability. Undoubtedly, private individuals, corporations, and sacred organizations (elders in secret societies and religious entities protecting sacred spaces) have played important roles in many places (Blomley, 2013; Sheridan and Nyamweru, 2008). However, descriptions of these devolved management systems are not easily accessible within most existing datasets.

In addition, many of the public forests in developing countries are legally controlled by the state, even though local villages, tribes, and other community organizations access the forests customarily for various products and services (Larson et al., 2008; Bruce et al., 2010). As a result, characterizing these cases as forest commons may not be adequate. Instead, they may be better characterized by the content and assurance of the particular "bundle of rights" associated with each system. In fact, forest tenure security can be achieved under a spectrum of property rights regimes, and these tend to evolve rapidly in relation to broader ecological, social, and economic factors. At the same time, government efforts to adjust the regulatory framework, provide information and other services, and build local capacity have been cited as important factors in affecting resource conditions and sustainable management (Chomitz et al., 2007). However, identifying causal linkages between forest outcomes and policy changes has not yet received sufficient attention in the literature reviewed.

Moreover, while understandable, it may not be an analytically relevant strategy to assess the performance of community-based forest management against that of government-managed protected areas. The importance of different legacies and thus different starting points facing different forests cannot be underestimated. Comparing the effectiveness of community based forest management schemes against protected area management by the state without acknowledging their different legacies and thus starting points is inappropriate, if not dangerous. Of course, this does not suggest ignoring the role of PAs in reducing deforestation and forest degradation and thus in reducing carbon emissions. PAs in tropical countries are managed under different governance regimes, and their relative effectiveness in avoiding deforestation has been the subject of much recent research. For instance, Nelson and Chomitz (2009) used matching methods to compare global PA points with similar unprotected points, controlling for slope, rainfall, road proximity, and other factors affecting both deforestation and PA placement. Unlike previous studies, this work provides a continuous measure of the effectiveness of protection as a function of varying degrees of deforestation pressure, as well as for different classes of protection (strict, multi-use, and indigenous). The authors found

that PAs generally have significantly lower fire rates than comparable non-PAs, but this differential declines as remoteness increases. Additionally, indigenous areas have an even higher protection impact.

Andam et al. (2008) also noted that conventional methods of evaluating the effectiveness of PAs could be biased because protection is not randomly assigned and because protection can induce deforestation spillovers (displacement) to neighboring forests. By applying matching methods to evaluate the impact on deforestation of Costa Rica's renowned PA system between 1960 and 1997, they showed that protection reduced deforestation: approximately 10 percent of the PAs would have been deforested had they not been protected. In comparison, conventional approaches substantially overestimate avoided deforestation (by over 65 percent). Moreover, they found that deforestation spillovers from protected to unprotected forests are negligible. Nolte et al. (2013) and Pfaff et al. (2014) further confirmed that all protection regimes helped to reduce deforestation in the Brazilian Amazon. For any given level of deforestation pressure, strict PAs, where no human use is permitted, consistently avoided more deforestation than sustainable use areas. Indigenous lands were particularly effective at avoiding deforestation in locations with high deforestation pressure. Holland et al. (2014) also demonstrated that different broad tenure regimes are significantly associated with deforestation rates. PAs provide the largest reduction in deforestation over time, but indigenous areas that overlap with some protection category (e.g., nature reserve) also result in forest conservation. However, private lands and indigenous reserves outside of national PAs experience the highest rates of deforestation.

These studies clearly demonstrate that, with appropriate empirical methods, conservation scientists and policymakers can better understand the relationships between human and natural systems and can use this knowledge to guide their attempts to protect critical ecosystem services. The major policy implications notwithstanding, they illustrate where the research on the linkages between devolved tenure systems and forest conditions should be heading. That is, the time has come for analysts of the effectiveness of forest tenure devolution to adopt similar matching methods in identifying appropriate references, or counterfactuals, i.e. what would have happened without the introduction of a devolved tenure system (Wooldridge, 2002; Imbens and Wooldridge, 2009). Included in matching methods are difference in differences, propensity score matching, and regime switch regression (Khandker et al., 2010). In fact, Ferrero and Pattanayak (2006) and Joppa and Pfaff (2009), among others, have argued that the field of conservation policy must adopt state of-the-art program evaluation methods to determine what works and how it works. Of course, even if a proper model has been developed for assessing the policy impacts, adequate inclusion of covariates in the socioeconomic and biophysical dimensions is essential. Viewed in this light, the narrow focus on a few institutional variables is worrisome.

An additional critique of the comparison of CBFM to PA is that PAs serve a different function than community-managed forests. Even if the government management of PAs is not very effective, it is unlikely that many governments would be willing to devolve PAs to be managed by communities. There are a number of broader management objectives that will not necessarily be provided through local community devolution. If the management of PAs is devolved to local communities, how can one make sure that the non-market ecosystem services or public goods will be sustainably provided over time? As posited by Shyamsundar and Ghate (2011), decentralization can lead to a mismatch between what is required from an ecosystem services perspective and what is known to work better from a social perspective. In forest and water management, for example, it is important to consider issues of upstream and downstream coordination, which can hardly be tackled entirely at the local level. Finally, it is worth mentioning that compared to the attention garnered by scrutinizing the effectiveness of PAs vs. CBFM, limited efforts have been directed to examining the performance of other state managed forests, such as production forest, which are by far the predominant category of forests in most countries.

Another issue that presents a common challenge is the deficiency of forest condition indicators used in a majority of studies. While forest area is commonly considered, growing stock, increments, and removals, let alone other indicators of forest health and functionality, have not been well scrutinized. As already highlighted, there exist good forest inventory systems in many countries, from which time-series data of forest area, stock, and other variables germane to diversity and health can be derived. Yet, it remains

uncommon for scholars to incorporate historical data derived from satellite images into their analyses of forest devolution and tenure reform. Nevertheless, it must be recognized that coupling current cover information and data of other variables is a poor approach, because current forest cover condition is determined by numerous historically derived influences.

As noted by Ostrom and Nagendra (2006, p. 19225), the challenge of good scientific observation of linked social-ecological systems is made even more difficult because relevant variables operate at different spatial and temporal scales, and their impacts differ radically. Thus, it is important to develop better methods for studying these linked systems across multiple levels. Because of these challenges, scholars seeking to understand the social-ecological factors related to forest management need to conduct long-term research programs using research methods that focus on dissecting temporal and spatial scales.

Further, more progress must be made in defining and enumerating the relevant variables and obtaining the corresponding information in the socioeconomic and biophysical domain. For instance, if economic incentives are key, then market price and/or taxation variables should be included; if economic growth has resulted in livelihood improvement and labor transfer, then growth, labor reallocation and urbanization variables are deemed relevant; if demographic pressure is high, then some density and/or resource dependency variables are needed; if lack of technical and financial capacity is a bottleneck, then funding and service variables should be considered; if the perceived and/or real insecurity of community, private, or other forest tenures is a constraint to sustainable management, then meaningful proxies should be devised to capture that. As to variables and data related to forest tenure and governance, a comprehensive reference is the manual of forest governance indicators that has been released by WRI (Davis et al., 2013). The World Bank has also developed relevant Forest Governance Indicators (PROFOR/FAO, 2011), as well as the Land Governance Assessment Framework (LGAF) (World Bank, 2013). With carefully defined variables and panel data, it becomes possible to build appropriate models, such as a system of equations or an impact evaluation model. These models will provide increased power in testing hypotheses of broad interest, quantifying and comparing policy impact, and confronting such technical issues as endogeneity (where the preexisting conditions of forests explain outcomes more than the variables of interest), multi-collinearity (where correlated institutional variables are used in the same model to describe outcomes), and time-lag (where not enough time is allowed for predictive variable to impact the outcomes of interest). Efforts to address these challenges will result in clearer understanding of causal relationships.

6.0 KEY FINDINGS AND RECOMMENDATIONS

This final section summarizes the major findings of this literature review of the empirical literature linking devolved forest tenure and forest conditions. Recommendations are presented to improve the applied research agenda on forest devolution and community forestry, including by addressing issues related to climate change mitigation and adaptation. The original hypothesis guiding this literature review, "*to test the hypothesis that devolved forest rights and management slows or reverses forest degradation*," remains largely untested, despite an accumulating amount of evidence. With an interest to promote the construction of forestry policies and programs based on empirical evidence, this literature review highlights the gaps in what we know about the complex social and economic relationships contributing to forest degradation and regeneration in an era of climate change. Devolved forest tenure is a key, but not the sole, contributing factor of forest conditions.

KEY FINDINGS

1. Over the last two decades, a growing body of literature has accumulated on the empirical linkages between devolved forest tenure systems and forest condition. The literature is still growing at a rapid pace and with an enhanced rigor. This is due largely to the improved availability of data as well as the increased salience of the issue of tenure and property rights in a world of REDD+ and payments for ecosystem services.

2. Devolution in the forest sector refers to the process of transitioning from centralized to decentralized forest management, which has been occurring at multiple levels—from the regional level to the community and individual. If one is interested in the impacts of devolved tenure systems on forest conditions, analyses should compare these different governance paths using a comprehensive perspective. The narrow focus on the relationship between forest condition and devolved property rights alone is less productive. Important changes in forest condition may be emerging around the world under vastly different tenure regimes, though the reasons for this are not fully understood.

3. The primary literature largely falls into local-level inquiries and regional-level analyses. Studies around the world do indeed examine the local-level interface between forest conditions and specific institutional variables like tenure and governance. Some broader regional-level analyses also examine the state of forests in relation to a broad array of institutional and other measures. Many analysts agree that while there is a linkage between forest tenure and forest condition, there are many interconnected variables that drive changes in the quantity or quality of forests. These variables include rights, rules, and institutions that function in particular social, economic, and ecological circumstances. Therefore, these factors should be incorporated into the modeling of causality. Yet, teasing out the primacy of any one variable remains difficult due to the lack of rigorously collected empirical data.

4. Substantive advances have been made in identifying the relevant variables and testing the causality between forest condition and community-based tenure. It is well understood that (1) in the context of governing common property forest resources, local rulemaking, enforcement, and monitoring are essential; and that (2) communities have better knowledge and a greater stake in sustaining their forests, but they may need adequate information and capacity to pursue major projects of forest establishment and maintenance. However, testing these relations of causality remains fraught with methodological challenges primarily related to how to identify the appropriate baseline for impact evaluation.

5. Forest tenure reform and institutional change can lead to improved forest condition as reflected in slowing down deforestation and forest degradation or accelerating reforestation. Despite the lack of strong data sets, case studies demonstrate these linkages, but these correlations are often tied to particularities of place and time.

6. Tremendous empirical gaps exist in terms of the quantity and quality of the evidence generated. The relationship between tenure regimes and forest condition is sometimes tenuous. There is no clear and robust evidence to suggest that a specific tenure type will ensure forest conservation. Although some prominent examples provide illustrations of the link between tenure security and forest condition, rigorous evaluation data are lacking, and many of the socioeconomic and biophysical factors have not been well captured in quantitative studies.

7. Much of the literature on the linkages between forest condition and community forest management relies on a limited number of case studies and simplistic comparative analyses. Statistically derived conclusions are rare, and, for this reason, questions remain about the robustness of the policy recommendations. As a result, knowledge about the magnitude, relative contribution, and even direction of influence of different causal mechanisms on forest management outcomes is still poor. Compared to the relatively well-researched Amazon Basin, the roles of devolved tenure systems in slowing or reversing deforestation in Southeast Asia and the Congo Basin have not received adequate attention. Likewise, until recently, relatively few studies have explored the relationship between devolution and mitigation of forest degradation.

8. A great deal has been documented of the positive roles that CBFM and JFM have played in reforestation and forest regrowth in India and Nepal, whereas the similar and perhaps even more profound developments in places like China and Sahelien West Africa have not been well examined. Little has been reported of the linkages between devolution and forest condition in the transition economies of former communist countries in Eastern Europe and Asia. Similarly, innovative policy forest policy reforms in Sahelian West Africa and their impacts on forested landscapes is only now being teased out. The causes of profound changes in forest cover in China are largely unknown to the West.

RECOMMENDATIONS

The following recommendations suggest options for strengthening strengthen future analyses of the linkages between forest resource tenure and forest condition.

- ***Delineate baselines for different forest types to assess the effects of devolved tenure systems.*** In so doing, it will be possible to better understand what would have happened to the quantity and/or quality of the forests in the absence of devolution—the so-called counterfactual process of testing hypotheses with solid evidence. As a result, the different forest contexts, including legacies and circumstances, can be adequately captured. Without examining closely the particular baselines and matching properly, making a cross-regime comparison (say, CBFM vs. PAs) is less productive, if not counterproductive.

- ***Adopt a two-pronged approach to data generation and modeling work.*** Both long-term monitoring and evaluation protocols and short-term data collection and analysis initiatives on forest condition and tenure causalities must be undertaken with a view to the current state of knowledge and the considerable policy and academic interests in the subject. Long-term monitoring is more suited for institutions interested in science-oriented basic research, whereas the latter option of short-term data collection and analysis is more desirable for organizations concerned about applied policy research. In the latter case, there must be a disciplined sampling scheme—not necessarily a large number of units, but the study sites should be representative and feasible for collecting the necessary field data.

- ***Select more balanced and representative sampling sites.*** The study sites for both long- and short-term monitoring should encourage comparison across countries and cultures of particular devolved

tenure systems and forest conditions. To that end, one way forward is to advance the analytical agenda to identify areas where forest recovery has occurred and then determine whether positive changes in forest status are linked to devolved tenure and governance. Another option is to identify multiple areas where devolution has been implemented over an extended period of time and whether forest conditions have indeed improved using a common baseline and change methodology. These approaches are dependent on the existence of strong baseline datasets. The above considerations lead us to suggest the following countries for possible fieldwork:

- *Asia*: India/China to feature reforestation and forest regrowth before and after tenure reform and institutional change;
- *Africa*: Niger, Burkina Faso and Tanzania to feature dynamics of forest regeneration and regrowth associated with policies and legislation around decentralization and devolution of tree tenure to local communities and individuals; and
- *Latin America*: Brazil and Bolivia to feature deforestation and forest degradation associated with indigenous reserves, protected areas, and open frontier expansion. This research should take note of the reconstitution of forest areas occurring on privately held lands.

- ***Capture the relevant biophysical and socioeconomic, as well as institutional, variables in any new data generating effort.*** The construction of longitudinal datasets should be supported over a period of at least 20 years and do so in a cost- and time- effective manner. Forest condition indicators (including deforestation, degradation, and reforestation) should come from historical inventory information, if possible. Otherwise, longitudinal datasets can be generated from satellite images analyzed roughly every five years. As noted above, however, analysis of satellite imagery, and associated ground-truthing, does not necessarily generate fine-grained empirical data on forest conditions.

  No matter the strategy adopted, it is essential to derive yearly observations for effective and efficient modeling work, which requires the data to be interpolated periodically so that the forest condition indicators are matched with socioeconomic, ecological, and other variables. The acquisition of forest inventory information for a particular study site should be done in cooperation with the national and regional forest institutions. Likewise, satellite images for the study site should be obtained from international space agencies and their partners.

- ***Seek innovative modeling frameworks and methods.*** To date, the modeling techniques used in impact evaluation—various matching methods—have rarely been applied to quantify the impact of a devolved tenure and governance system on changes in forest conditions. With the availability of longitudinal data, the use of simultaneous equations also becomes possible. Interpretation of quantitative data through rigorous regression analyses and associated modeling may lead to more convincing arguments around multiple causalities influencing forest condition and complex feedback effects.

ANNEX A: SUMMARY OF INQUIRIES AT THE LOCAL AND REGIONAL LEVELS AND SELECTED CASE STUDIES

TABLE 1. LOCAL-LEVEL STUDIES

Author(s), year & journal of publication[1]	Title	Method(s) and data[2]	Key findings[2]
Gibson, et al., 2005, WD	Local enforcement and better forests	Correlation test of 178 user groups from multiple countries	Regular monitoring & sanctioning led to better FC
Hayes, 2006, WD	Parks, people, and forest protection: an institutional assessment…	Vegetation density (VD) comparison between 76 parks and 87 non-parks and correlation test between VD and institutional variables from multiple countries	No VD difference; and user rulemaking positively correlated with VD
Agrawal & Chhatre, 2006, WD	Explaining success on the commons: community forest governance…	FC is a function of biophysical, economic, and many other variable; 95 cases of community forests in India Himalaya	Biophysical factors influence socio-cultural conditions and resource outcomes
Nagendra, 2007, PNAS	Drivers of reforestation in human-dominated forests	Association between FCC and tenure regime, monitoring and other variables; 55 forests in Nepal	Tenure regimes and local monitoring are important to forest regrowth
Chhatre & Agrawal, 2008, PNAS	Forest commons and local enforcement	Logit regression of FCC vs. rule enforcement, user group size, importance of forest, etc.; 152 forests in 9 countries	Levels of local enforcement have a positive relationship to the probability of FR
Chhatre & Agrawal, 2009, PNAS	Trade-offs and synergies between carbon storage and livelihood benefits from forest commons	Logistic regression of joint outcomes of carbon storage and livelihood benefits vs. forest size, decision making autonomy, etc.; 80 forests in 10 countries	Size of forest commons and degree of rulemaking power associated with outcomes in different ways
van Laerhoven, 2010, GEC	Governing community forests and the challenge of solving two-level collective action…	Addressing whether governance matters in FCC and how good governance regimes would emerge	Governance matters and odds are high for a group to solve problems if it is organized and has experience
Persha et al., 2011, Science	Social and ecological synergy: local rulemaking, forest livelihoods, and biodiversity conservation	Logistic regression of joint outcomes of livelihoods and biodiversity vs. social-ecological factors; 84 sites in 6 countries	Outcomes have to do with local rulemaking; size of forest and livelihood value are also important

Note: [1]WD = World Development, PNAS = Proceedings of National Academy of Sciences, and GEC = Global Environmental Change
[2]FC = forest condition, FCC= forest condition change, FR=forest regeneration, PA = protected area.

TABLE 2. REGIONAL-LEVEL STUDIES

Author(s), year & journal of publication[1]	Title	Method(s) and data[2]	Key findings[2]
Andersson & Gibson, 2007, JPAM	Decentralized governance… local institutional moderation of deforestation in Bolivia	Regression of D vs. local institutions, national policy, etc.; 30 municipalities	Local institutional affects unauthorized D, but has no effects on permitted D.
Andersson et al., 2010, Conference paper	Decentralization and D: comparing local forest governance regimes in LAC	Lagged FC vs. de facto/de jure decentralization, importance of forestry, etc.; 217 entities in 3 countries	Municipalities with more autonomy had less D and invested more; de facto devolution more important
Yin and Newman, 1997, EDE	Impacts of rural reforms: the case of the Chinese forest sector	Regressing regional harvest, volume, and area against the major policy reforms; panel data of 4-5 prefectures in 12 years	Variable regional responses to HRS and price liberalization show the role of entailed incentive and security
Nagendra et al., 2008, LE	Forest fragmentation and regrowth in an institutional mosaic… in Nepal	Land cover change/modification during 1989-2000 matched with management regimes	Significant differences in land cover dynamics and spatial pattern between different "ownership classes"
Larson et al., 2010, IFR	New rights for forest-based communities? Understanding forest tenure reform	Whether community rights improved in terms of the origins, nature and initial outcomes of tenure reform; 30 sites in 10 countries	Rights granted to collectives rather than individuals; more positive outcomes in Asia, mixed in Africa, and no change in LAC
Araujo et al., 2009, EE	Property rights and deforestation in the Brazilian Amazon	Usual determinants of D plus a measure of property rights insecurity; annual obs in 9 states over 1988-2000	Insecure property rights in land drive deforestation

Note: [1]IFR=International Forestry Review, JPAM= Journal of Policy Analysis and Management, EDE=Environment and Development Economics, LE=Landscape Ecology, EE=Ecological Economics
[2]D=deforestation, FC=forest cover, LAC=Latin America

TABLE 3. SELECTED CASE STUDIES

Author(s), year & journal[1]	Title	Main result(s)
Klepeis, 2003, LDD	Development policies and tropical deforestation in the Yucatán: Centralized and decentralized approaches	Historical analysis in identifying key drivers of deforestation is needed and centralized land management resulted more resource exploitation
De Oliveira, 2008, FPE	Property rights, land conflicts and deforestation in the Eastern Amazon	Insecure property rights are the main causes, compatible environmental goals and agrarian policies are necessary
Gibson et al., 2007, CS	Explaining community-level forest outcomes: salience, scarcity, and rules in eastern Guatemala	Resource dependent community and perceived scarcity are two conditions for individual choice to invest time in a collective solution; biophysical and socioeconomic factors are not ignorable.
Paneque-Gálvez et al., 2013, AG	Land tenure and forest cover change: the case of southwestern Beni, Bolivian Amazon, 1986-2009	Land tenure played a key role in forest cover change except in private forests
Nepstad et al., 2006, CB	Inhibition of Amazon deforestation and fire by parks and indigenous lands	Reserves reduced both deforestation and fire significantly.
Curran et al., 2004, Science	Lowland forest loss in protected areas of Indonesian Borneo	Logging permits issued by local governments in the decentralization reform accelerated deforestation rates
McCarthy, 2004, WD	Changing to gray: decentralization and the emergence of volatile socio-legal configurations in central Kalimantan, Indonesia	Decentralization produced a race to forest sector due to the ambiguity in rights and rules
Tacconi, 2007, GEC	Decentralization, forests and livelihoods: theory and narrative	Decentralization coincided with a significant deterioration of the rule and law
Nagendra et al., 2008, LE	Forest fragmentation and regrowth in an institutional mosaic of community, government and private ownership in Nepal	Differences in the extent and spatial pattern of forest cover change are corresponding to different levels of government protection, access, and monitoring
Baland et al., 2010, WD	Forests to the people: decentralization and forest degradation in the Indian Himalayas	CBFM have been successful in regulating firewood and fodder extraction by locals and but not tree-cutting, timber, grazing or encroachment
Topp-Jørgensen et al., 2005, BC	Community-based monitoring of natural resource use and forest quality in montane forests and miombo woodlands of Tanzania	Devolution of ownership and management responsibilities to local communities is a key element of the new Tanzanian forest policy
Blomley et al., 2008, Oryx	Seeing the wood for the trees: an assessment of the impact of PFM on forest condition in Tanzania	Participatory forest management appears to be contributing to sustainable forest management
Oyono, 2005, JED	Profiling local-level outcomes of environmental decentralizations: The case of Cameroon's forests…	Decentralizing the management didn't lead to positive outcomes and a monitoring framework is recommended
Ribot et al., 2010, EC	Democratic decentralization in sub-Saharan Africa: its contribution to forest management, and livelihoods	Expected benefits of democratic decentralization were rarely realized because it had rarely been established

Notes: [1]LDD= Land Degradation & Development, FPE= Forest Policy and Economics, CS=Conservation and Society, AG= Applied Geography, CB= Conservation Biology, WD=World Development, LE= Landscape Ecology, PNAS= Proceedings of the National Academy of Sciences, BC= Biodiversity and Conservation, JED= Journal of Environment & Development, EC= Environmental Conservation.

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