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THE EVIDENCE BASE FOR COMMUNITY FOREST MANAGEMENT AS A MECHANISM FOR SUPPLYING GLOBAL ENVIRONMENTAL BENEFITS AND IMPROVING LOCAL WELFARE

Systematic Review

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Summary

Background

Rates of deforestation and forest degradation are high in many countries, leading to concern about the loss of ecosystem services such as carbon storage, biodiversity conservation, water and food security. Sustainable forest management (SFM) aims to "*maintain and enhance the economic, social and environmental values of forests for the benefit of present and future generations*". In pursuit of SFM, many developing nations have devolved full or partial forest management authority to local communities. This devolution is expected to result in more effective forest management, conserving biodiversity while also contributing to poverty reduction and economic development. Approaches to such community forest management (CFM) have in common the involvement of people who live in and around the forest in the management decisions that affect forest use and conservation. In the context of this review, we define community forest management as '*de-jure*' government-approved forms of forest management by local communities, with the following characteristics: 1. a core objective of providing local communities with social and economic benefits whilst promoting the sustainable management of community- or state-owned forests and/or 2. some degree of control and decision-making power vested in the community by the government (or other designated authority). The evidence base for effectiveness of CFM approaches is not well documented. This review characterizes the empirical evidence that CFM can generate global as well as local and regional/national environmental benefits.

Objectives

The primary review question is 'Does Community Forest Management supply global environmental and local welfare benefits in less developed countries?'

Methods

Multiple electronic databases, internet engines, and the websites of specialist organisations were searched to identify published and unpublished literature relevant to the review question. A range of keywords in English, Spanish and French were used. Bibliography checks were performed to complement the main search.

Predefined inclusion criteria were applied to each article in order to identify the subset to be included in the review:

Relevant subject(s): Any forest ecosystem or human population associated with a CFM programme in less developed countries.

Types of intervention: CFM programmes in less developed countries.

Types of outcome: a. changes to: biodiversity (surrogate measures of), forest cover or forest condition, fuel wood availability, carbon sequestration (any measure), land degradation or conversion, forest loss, desertification, forest productivity (wood and non-wood), water supply; b. changes in the following local welfare indicators: income, employment, food security, social equity, income equality, health.

Types of study: Studies providing empirical data, qualitative or quantitative. Only those studies making explicit comparisons between CFM and 'no CFM' were included in the analysis.

Relevant articles were grouped by outcome into three pools: those examining the impact of community forest management on forest cover and condition; resource extraction; and livelihoods. Information on methodology, study characteristics and results were extracted from each study and recorded. Due to the diversity of studies, meta-analysis was not appropriate for the majority of outcome types: this was therefore conducted on a subset of studies when possible, and a qualitative synthesis conducted for those remaining.

Main results

In total, 42 articles were included in the review, of which 34 reported data on forest condition or cover, eight on resource extraction (fuelwood collection and number of cut stems) and 13 on livelihoods.

Four studies that compared percentage forest cover before and after CFM, obtained with satellite data, show a range of effect sizes (including one negative). Three studies that compared percentage cover with a similar area of forest under alternative management suggest only moderate differences in forest cover between the different management systems.

More data were available on measures of forest condition (tree stem density, basal area, tree/plant diversity or richness) and these were synthesized in a meta-analysis. Based on data from eight studies, basal area and tree stem density were greater in forests, which in some cases included plantations, with CFM than those under either state management or no management. However, there was no consistent effect of CFM on species richness (seven articles) or diversity (five articles) compared with other types of management. There were insufficient data to investigate the relative effects of different types of management.

Meta-analysis of data from four studies indicated that incidence of cut stems was lower in forests with CFM but this trend was not consistent across studies. Only three articles presented data on fuelwood collection and two of these suggested greater collection amounts with CFM.

Articles investigating the impact on livelihoods were variable in the type of data they collected and presented, which prevented quantitative synthesis. Data types were grouped into financial capital (sources and levels of income), social, human, physical and political capital.

Conclusions

The available evidence suggests that some benefits of CFM might be achieved in terms of forest condition. This could potentially indicate a global benefit through an increase in carbon sequestration. However, the reliability of the measured variables as robust indicators of broader aspects of forest condition needs to be verified. Other causes of the reported increases in variables such as tree density and basal area cannot be ruled out, such as differences in forest condition between sites that are selected, or

not selected, for CFM. Most studies do not collect the necessary baseline data or other relevant information to be able to investigate this potential selection bias. There is no evidence of benefit to biodiversity conservation based on analysis of data on plant species richness or diversity. However, these findings should be considered in the context of the timescales of measurement, specifically how long the management had been in place before measurements were taken, and timescales over which these biological variables could be expected to respond. Various 'livelihood outcomes' have been measured. However, there is insufficient evidence to conclude what effect CFM has on local livelihoods, which is in part due to the absence of consensual indicators of CFM success in improving livelihoods.

Within the *a-priori* defined limits of this review, synthesis and interpretation of data from the current evidence base is hampered by the methodological design and diverse outcomes used to measure the effects of CFM. Whilst one must be aware of the difficulties of conducting high quality studies, a minimum quality of study design, which will contribute useful data to inform the evaluation of CFM initiatives, whilst also being realistically feasible, should be provided for guidance to practitioners and proponents of CFM projects. Standard outcome measures that are recognised indicators of the success of a particular management should be agreed so that they are common across projects. This would allow quantitative synthesis of data to make more general inferences of the effects of CFM rather than just accumulating disconnected case studies of specific sites. Higher standards of reporting within articles on study context, and other factors that may explain differences between CFM and non-CFM sites are essential to attempt any meaningful analysis of the effect of CFM and investigation of factors driving variation in effectiveness of CFM among different sites. If research is better integrated into CFM project activities this should result in higher quality evidence about the actual direct effects of the project interventions.

1. Background

Rates of deforestation and forest degradation are high in many countries, leading to concern about the loss of ecosystem services such as carbon storage, biodiversity conservation, water and food security (as reflected in the United Nations' conventions on biological diversity and climate change, the Forest Principles of UNCED and Agenda 21). Therefore there is an international effort to move towards a more stable and sustainable state for forest condition and management (e.g. through the work of the UN Forum on Forests). At the same time it has been increasingly recognised that many of the world's poorest people get significant resources from forests (Byron and Arnold 1999; Godoy 2000; Campbell and Sayer 2003) and national forest policies increasingly consider local people's needs. In fact, to meet the Millennium Development Goals, countries have pledged to ensure that policies designed to conserve internationally important ecosystem services in forests fully take account of impacts on local livelihoods.

Sustainable forest management (SFM) aims to "*maintain and enhance the economic, social and environmental values of forests for the benefit of present and future generations*".[1] Among the objectives of SFM is the conservation of biological diversity; prevention, control and reversal of land degradation; mitigation of desertification; mitigation of, or adaptation to, climate change; and the production of wood and non-wood forest products and services.

In pursuit of SFM, many developing nations have devolved full or partial forest management authority to local communities (Bray et al 2003; Somanathan et al 2009). This devolution is expected to result in more effective forest management, conserving biodiversity while also contributing to poverty reduction and economic development. Approaches to such community forest management (CFM) go by many names and forms: co-management, joint management, participatory management, community-based forest management, indigenous reserves. Despite the differences in names and emphases, they have in common the involvement of people who live in and around the forest in the management decisions that affect forest use and conservation. In the context of this review, we define community forest management as:

De jure, government-approved forms of forest management by local communities, with the following characteristics:

1. a core objective of providing local communities with social and economic benefits whilst promoting the sustainable management of community- or state-owned forests[2]

and/or

2. some degree of control and decision-making power vested in the community by the government (or designated authority).

The argument for decentralisation of forest management in developing countries is that shortage of resources and poor infrastructure have often resulted in a lack of

[1] As adopted in the "Non-legally binding Instrument on All Types of Forests" (NLBI) at the seventh session of the United Nations Forum on Forests (UNFF), April 2007.

[2] We adopt the FAO's definition of "forest" presented in the 2005 Global Forest Resources Assessment (http://www.fao.org/docrep/007/ae156e/AE156E03.htm#TopOfPage).

effective state control (Curran et al 2004). It is hoped that devolving management rights and responsibilities to local people will avoid a 'tragedy of the commons' and encourage local people to actively manage the forest resulting in both ecological and economic benefits. It has been suggested that these benefits are realized at local, national and global scales.

CFM approaches are growing in popularity at the national level and attracting increasing funding from international organisations. The effectiveness of CFM approaches, however, is not well documented despite this being important for informing the development of evidence-based policy. This review characterizes the empirical evidence that CFM can generate global environmental benefits (i.e., public goods not confined to the nation in which the CFM occurs, e.g. biodiversity conservation, carbon sequestration), as well as local benefits (i.e., benefits to communities entrusted with management authority, e.g. changes in household income, food security) and regional/national environmental benefits (i.e., public goods within the nation with the CFM, e.g. watershed protection). This review collates and appraises studies that compare measurements in a forest/village with CFM with a forest/village without CFM implementation (or alternatively before CFM implementation); this direct comparison provides the opportunity to measure the effect of CFM independent of changes in environments/livelihoods due to other causes.

2. Objectives

2.1 Primary objective

Does Community Forest Management supply global environmental and local welfare benefits in less developed countries?

Table 1. The elements of the systematic review question defined.

SUBJECT	INTERVENTION	OUTCOME MEASURE	COMPARATOR
a. - Forest ecosystems b.- Human populations	Community forest management programmes in Less Developed Countries	a. Change in biodiversity, forest cover, forest condition, fuel wood availability, carbon sequestration, measures of land degradation and desertification, forest loss, land conversion, forest productivity (wood and non-wood), b. Measures of local human welfare: income, employment, income equality, social equity, food security, health.	Without and/or before/after CFM .

3. Methods

3.1 Question formulation

This review was commissioned by the Scientific and Technical Advisory Panel of the Global Environment Facility (GEF) who are interested in the evidence base for the effectiveness of CFM because the GEF is funding CFM initiatives. Thus the broad question for review was developed by the GEF and its Science Panel. The question components were refined by subject experts within the review team and, following a brief period of scoping, the focus of the review was restricted to community forest management in developing nations reflecting the availability of relevant literature. The question breakdown is shown in Table 1.

3.2 Search strategy

The search aimed to capture an unbiased and comprehensive sample of the literature relevant to the question, whether published or unpublished. Thus, a number of different information sources (general and specific) were searched in order to maximise coverage.

3.2.1 General Search

The first part of the literature search involved the use of a wide range of academic literature databases as well as a number of internet search engines: a full list of the sources used for this review is presented in Appendix B.1. Given the many thousands of results returned by internet search engines, these searches were restricted so that the first 100 hits from each search were checked for relevance and any links to potentially relevant material followed only once from the original hit.

3.2.2 Specific Search

This part of the search took two forms: the first, given the focus of the review on interventions of the type run by the GEF family of organisations, was direct contact with the GEF agencies (see Appendix B.2) to identify any relevant material in their data holdings; and the second, searching of a number of specialist organisation websites (listed in Appendix B.2). In order to improve efficiency, this search was restricted to the publications section of these websites where one was available.

3.2.3. Search terms

Discussion with subject experts and iterative testing of individual terms allowed the identification of an appropriate set of search terms for use in the database and internet search engines. These were combined using Boolean operators where possible and utilised truncation/wild card symbols (denoted by *) to search alternative word endings:

- “community forest*”;
- “community-based forest*”;
- (“co-management” AND forest*);
- (“joint management” AND forest*); “JFM”;
- "participatory forest*”;

- “indigenous forest* reserve*”;
- “decentrali* forest*”;
- “integrated conservation development pro*”; “ICDP*”;
- “community-based natural resource*”;
- (community AND "natural resource management" AND forest*);
- (“common property AND forest*)

Where database or search engine capability precluded the use of multiple terms or lengthy search strings, a single term “community forest management” was used for efficiency.

Foreign language internet searches (see B.1), in French and Spanish, have been conducted[1] using combinations of the following terms:

- “Manejo Forestal Comunitario”; “Ejido forestall”; “Desarrollo forestal participativo”
- “Gestion communautaires (ou villageois) forêt”; “Gestion autorités communales forêt”; “La foresterie communitaire”; “Foresterie pour le developpement rural”; “Transfert de Gestion”.

The reference sections of studies included in the review, as well as review papers and meta-analyses identified by the search, were examined for any further relevant citations not already captured. During the draft review consultation period, subject experts and key authors were contacted for additional references that may have been missed by the original search. Any additional studies were included into the final report version.

3.3 Study inclusion criteria

In order to select those articles that were relevant to the review question from those initially captured by the search, a set of inclusion criteria were developed prior to the start of the review and are as follows:

Relevant subject(s): Any forest ecosystem or human population associated with a CFM programme in less developed countries.

Types of intervention: CFM programmes in less developed countries.

Types of outcome: a. changes to: biodiversity (surrogate measures of), forest cover or forest condition, fuel wood availability, carbon sequestration (any measure), land degradation or conversion, forest loss, desertification, forest productivity (wood and non-wood), water supply; b. changes in the following local welfare indicators: income, employment, food security, social equity, income equality, health. We included studies which report any direct measure of these indicators, prioritising for analysis those which present quantitative measurements and/or use validated scores.

Types of study: Studies providing empirical data, qualitative or quantitative data, were included in the review. We prioritised for analysis those studies making explicit

[1] These searches are complete and the articles are currently being examined for relevance. To date, only one additional potentially relevant article has been identified which is being translated.

comparisons between CFM and 'no CFM': these within-study comparisons may have been made on the basis of internal or experimental comparators (i.e. before-after; intervention A v intervention B), or through the use of constructed comparators (i.e. studies which use external data sets or models to develop scenarios for comparison). Studies without comparators were classified and recorded.

The relevance assessment process was a three-staged one. In the first instance, the inclusion criteria were applied on the title only to remove spurious citations. The remaining articles were then filtered by examining their abstracts, and finally by viewing the remaining articles at full text. Hits from web searches were filtered initially with the inclusion criteria on the abstract of articles (or introduction section or equivalent if an abstract is not available), and then at full text. In cases of uncertainty, the reviewer tended towards inclusion and sought the opinion of a second reviewer to determine final inclusion.

To check for consistency in the application of the inclusion criteria, two reviewers applied the inclusion criteria to a sample of 200 articles at the abstract filter stage. The kappa statistic was calculated to measure the level of agreement between reviewers. Following discussion to clarify the interpretation of the inclusion criteria, a kappa score of 0.68 was achieved, indicating "good" agreement (Landis & Koch 1977).

3.4 Study characterisation & quality assessment

General characterisation: In order to provide some characterisation of studies which investigated the effects of CFM but did not present a relevant comparator for inclusion in our synthesis, we recorded from each article: the type of CFM (based on author's terms); the country in which data were collected; and the broad outcome measures of CFM effects.

Detailed characterisation: For those studies with appropriate comparators, we recorded, when available, a range of variables. In addition to recording the general information as per above, we focussed particularly on aspects of the study methodology that have implications for the reliability ('interval validity') and generalisability ('external validity') of study findings. This also allowed us to assess the reporting quality of articles. Recorded characteristics included elements of the following:

- Geographic context of study
- CFM features/implementation: type, number of sites, age of management and size of forest area; any information on CFM implementation
- Comparator features: before/after or site comparison (type of site comparison)
- Selection of CFM and comparator sites and the sampling/selection within each.
- Confounders: variables that may confound the effects of CFM (e.g. bias in initial placement of CFM initiatives) and the ability of the authors to account for this (base-line data, collection of variables that may differ between sites; confounders included in analysis; data presented on distance between sites).
- Methodology used to collect data: basic techniques/instruments used, sampling within each site.

- Outcomes (i.e. variables measured that may indicate the effects of CFM): the types of outcomes collected and presented by a study and the potential of data presented for meta-analysis.
- Reasons for heterogeneity: details of any investigation/discussion of factors that may explain variation in the effects of CFM as reported by the authors.
- Author's conclusion: a coarse scale on the strength of support the authors conclude on the effectiveness of CFM.

This list is not exhaustive and the full list of items is available in Appendix C.

3.5 Data extraction and synthesis

As part of the initial study characterisation, we recorded the 'potential for meta-analysis', which entailed interrogation of the data presented and consideration of whether a mean and variance of the outcome with and without CFM could be calculated. Thus, where suitable data could be extracted, we pursued calculation of effect size and meta-analysis of the most common outcome measures. In studies measuring forest condition, the most common outcome measures were tree density, forest basal area, plant species richness (trees or trees/shrubs and herbs) and species diversity (trees or trees/shrubs and herbs) and in studies measuring resource extraction, the number or density of cut stems in a forest was the most common. We synthesise data on each of these five outcome measures with meta-analysis.

For each outcome measure, an effect size was calculated using Hedges *g*, which is based on the difference between means in each group divided by the pooled standard deviation (Cooper and Hedges, 1994) to create a unit-less measure of effect. Calculation of standard deviation was based on units of replication at the forest or forest division level, depending on the manner in which data were presented in the article. For most articles, one effect size per outcome per study was calculated however in a few cases the data presented were split by an additional factor and in these cases, effect sizes were based on levels of this factor (e.g. JFM plantations/control and JFM natural forest/control from Aggarwal et al. 2006). Heterogeneity in effect size among different studies was investigated with Cochran's Q statistic. Random effects models were used to estimate the overall average and confidence intervals, which weights individual studies by the inverse of the sum of its effect-size variance and between-study variance. The significance of the overall average effect was assessed by whether its confidence interval overlapped zero.

For other outcomes, apart from those five listed above, we did not pursue a meta-analysis because of the low number of studies which could be synthesized. Instead, we tabulated the averages of outcomes with and without CFM, and present effect sizes when possible, to illustrate the trends observed in the data. In these cases, log response ratios, which can be calculated without a measure of variance that is required for meta-analysis, is used to indicate the direction and relative size of effects. Where studies have not presented data in the form required for meta-analysis, authors were requested to provide any unpublished material or missing data that may be relevant to the review.

4. Results

4.1 Review statistics

The literature search returned 6355 articles, after duplicate removal (Figure 1): 3384 remained after checking of titles. Following abstract assessment, 635 (c. 10% of those initially retrieved) were accepted for assessment at full text. Of these articles, 16% were accepted at the full text assessment stage: 42 of these articles were found to present studies with appropriate comparators and thus were included in the synthesis (listed in Appendix D); the remaining 62 articles without comparators are characterised in Appendix E.

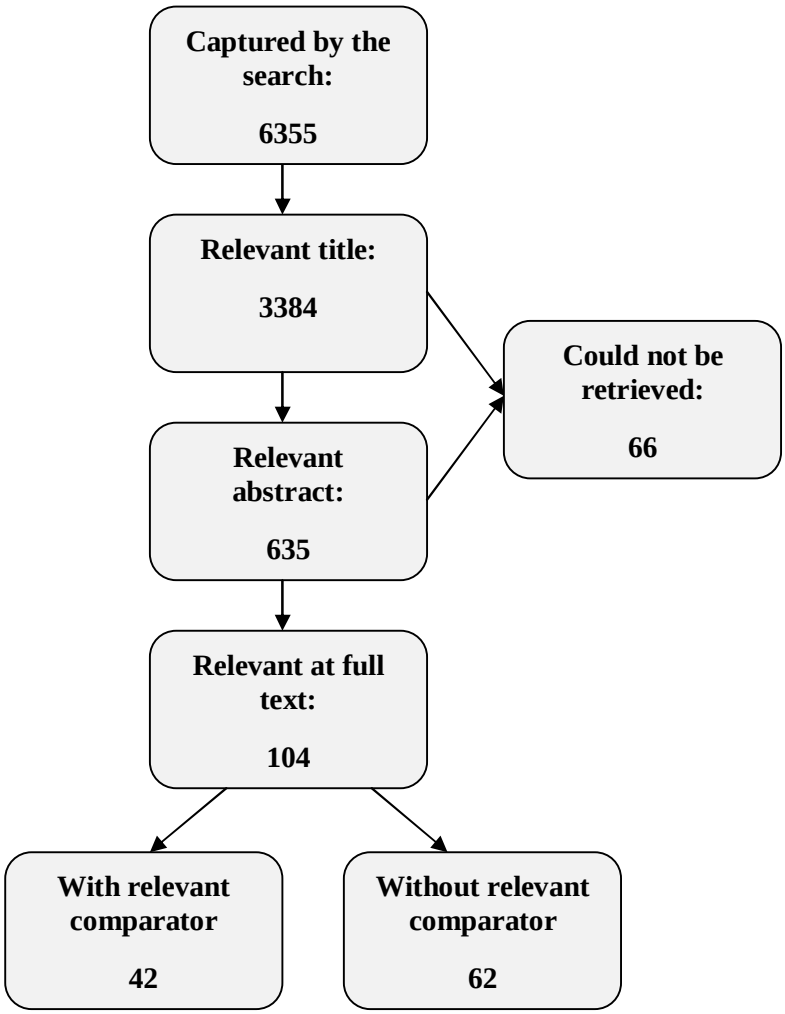


Figure 1. Number of articles retrieved in the review search and passing each stage of relevance assessment.

4.2 Description of studies

A list of included articles is provided in Appendix A. The following section provides a characterisation of the studies reported in the 42 articles included in the synthesis (some of these articles presented more than one study). A detailed description of each of these articles is presented in Table D1, Appendix D.

4.2.1 Source

Of those articles included, only 4 (c. 10%) came from non-peer reviewed sources and the remaining 38 (c. 90%) were published in peer reviewed journals. The large majority of studies (88%) were published after 2001. This represents an average of 1 paper per year up to 2001, increasing to 4.8 after 2001. Note that the database search was conducted during 2009 and thus this figure may not be representative of the whole year.

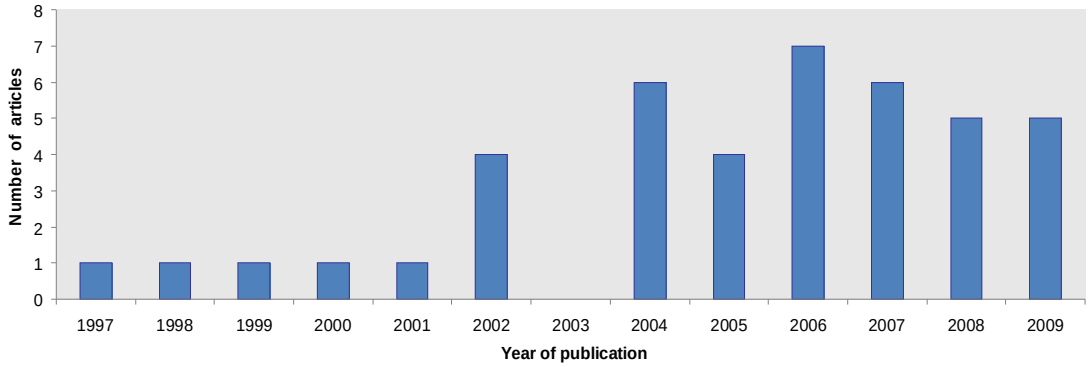


Figure 2. Year of publication of articles included in the synthesis. N=42

4.2.2. Focus

a) Study location

The geographical focus of the majority of the accepted studies is Asia (70%), dominated largely by India and Nepal, which together accounted for 59%; 16% were in Central America; and 14% in Africa (Figure 3). None of the captured studies examined CFM interventions in South America or Oceania.

b) Study comparator

Only 23% of the included studies examined outcomes before and after the implementation of CFM. The majority (77%) used comparisons with alternative management approaches, particularly comparisons of CFM outcomes with those from areas under state management, protected areas, or under unspecified 'non-CFM' management (Figure 4).

c) Type of CFM

The authors' descriptions of the project intervention are presented in Figure 5. Although some terms were clearly a result of national policy (e.g. 'joint forest management' in India and 'community forestry' in Nepal) and thus we can expect the nature of the intervention to be relatively uniform across projects using the same terminology from the same country, on the whole terminology could not be used to characterise or distinguish different approaches to CFM. The dominance of 'community forestry' and 'joint forest management' as the terms used (Figure 5) reflects the dominance of studies from Nepal and India in the set.

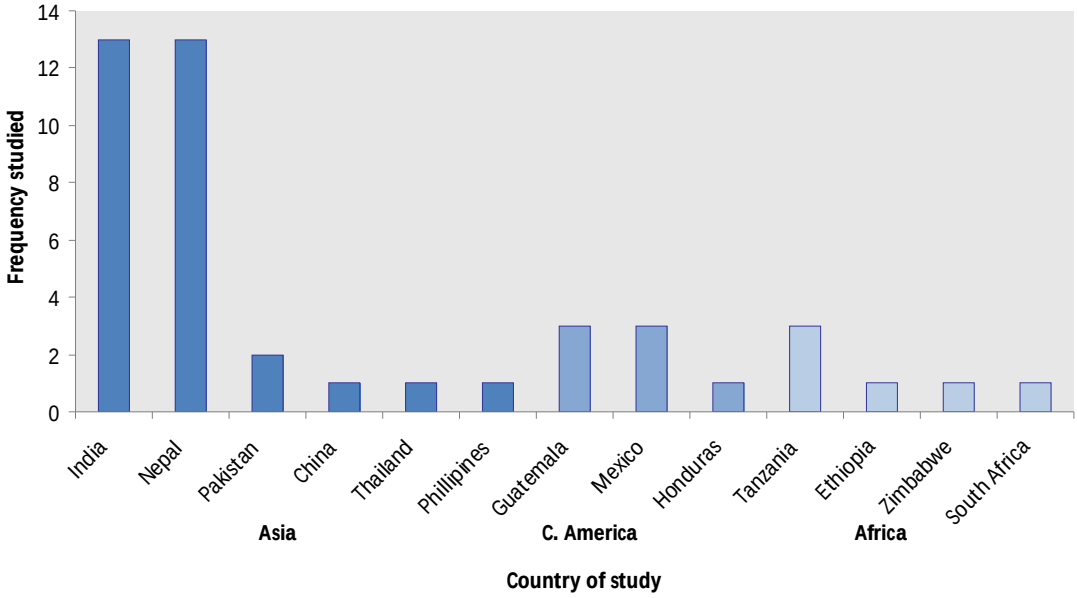


Figure 3. Location of studies included in the synthesis. Note that two articles studied multiple locations, hence n= 44.

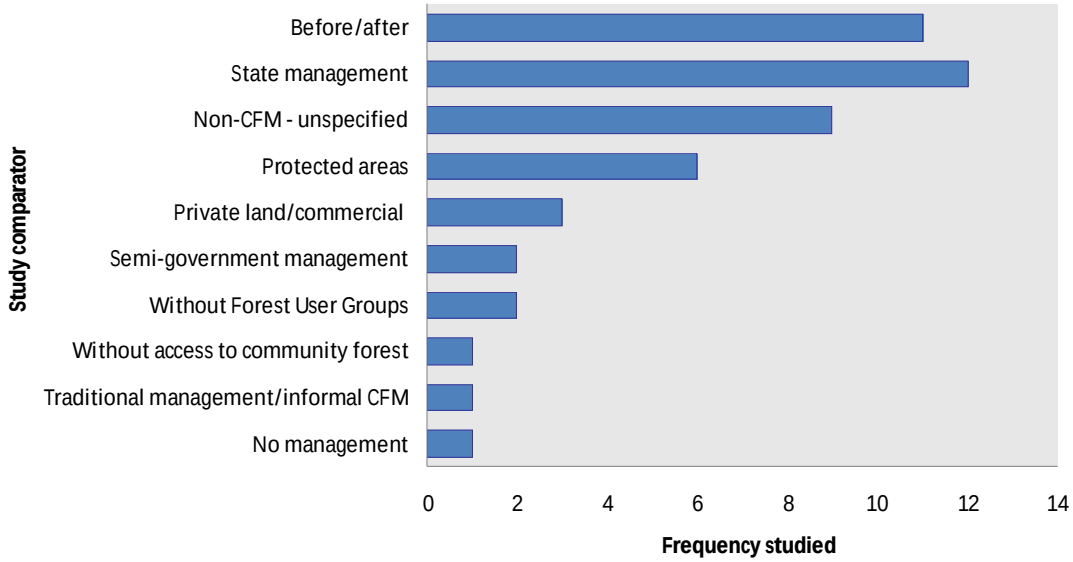


Figure 4. Nature of study comparators presented in included studies. Note n=48, accounting for those studies making multiple comparisons.

d) Measured outcome

The 42 studies reported 51 outcomes, which were classified into three broad groups in terms of the relevant outcomes that they reported: forest condition and land cover (32 studies); resource extraction (7 studies); and livelihoods (12 studies). Nine studies reported more than one outcome type therefore outcomes are not all independent data points. Figures 6-8 present a breakdown of each of these three broad groups (respectively) into more specific outcomes.

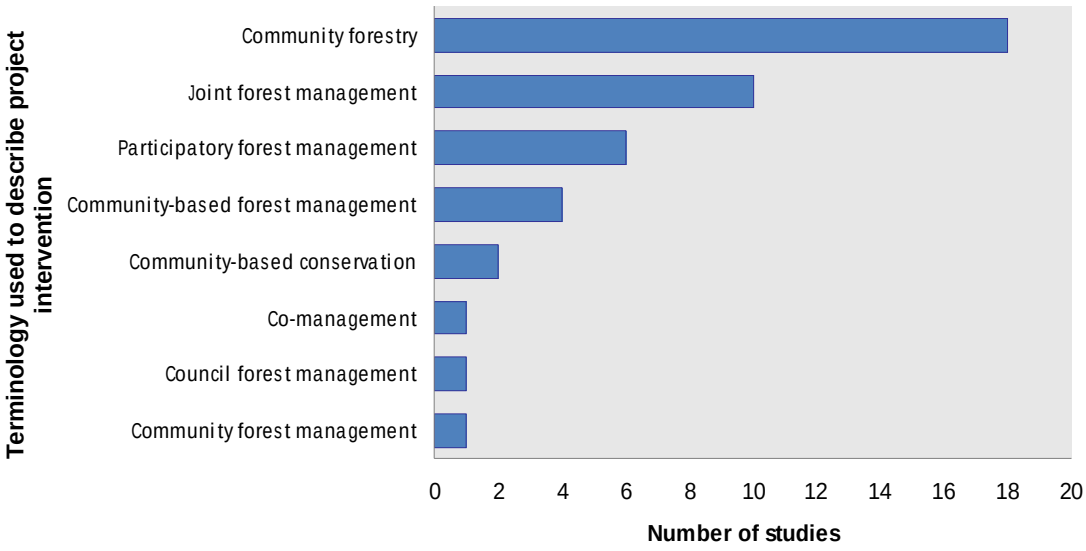


Figure 5. The range and frequency of terminology used to describe the projects' community forest management intervention in the included studies. N=43, reflecting that one article presented two different CFM 'types'.

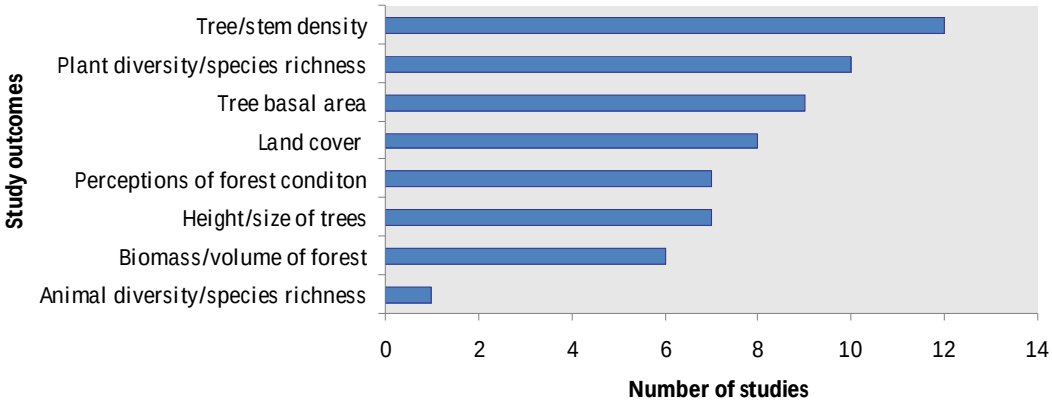


Figure 6. Number of studies giving each specific outcome category in the forest condition and land cover group. N=34, most studies reported multiple specific outcomes).

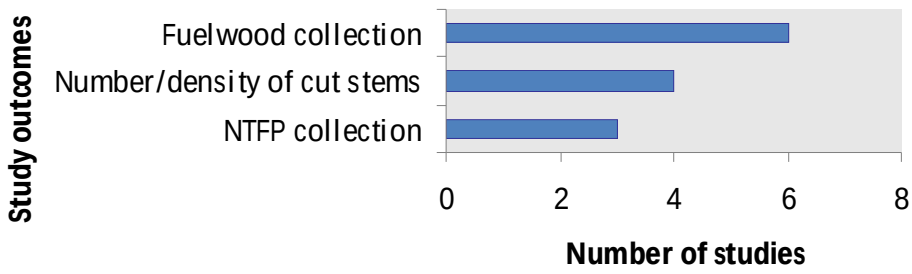


Figure 7. Number of studies giving each specific outcome category in the resource extraction group. N=8; some studies gave multiple specific outcomes. NTFP is non-timber forest products.

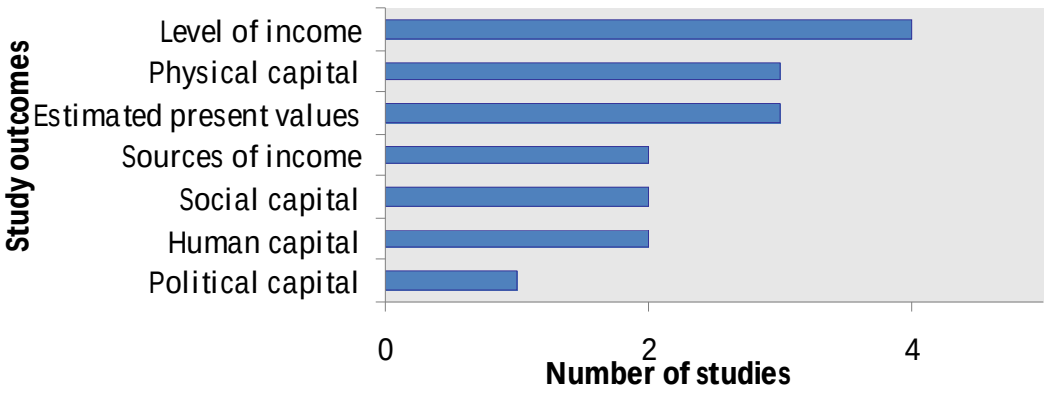


Figure 8. Number of studies giving each specific outcome category in the livelihood group. N=13; some studies gave multiple specific outcomes.

4.2.3 Study designs and methodology

Studies included in this review varied in their study design; basic details of the methodology of the studies are summarised in Figure 9. Most studies were comparisons of sites with and without CFM, without any baseline data collected from before the CFM was imposed; baseline data would allow assessment of the comparability of sites before management. Seven studies reported having some baseline data but only two of these also had control/comparator sites and in both cases the collection and presentation of baseline data were limited in the article (Kumar 2002; Maharjan et al. 2009), which prevented analysis of their findings as a BACI (Before-After-Control-Intervention) design. Studies investigating forest condition mostly employed a quantitative methodology using plots or transects to sample outcomes directly in the forest although some also used qualitative research methods to investigate user perceptions of forest condition. Studies investigating livelihood outcomes generally used mixed methods including a combination of quantitative survey data (e.g. questionnaire) and qualitative research methods such as semi-structured interviews.

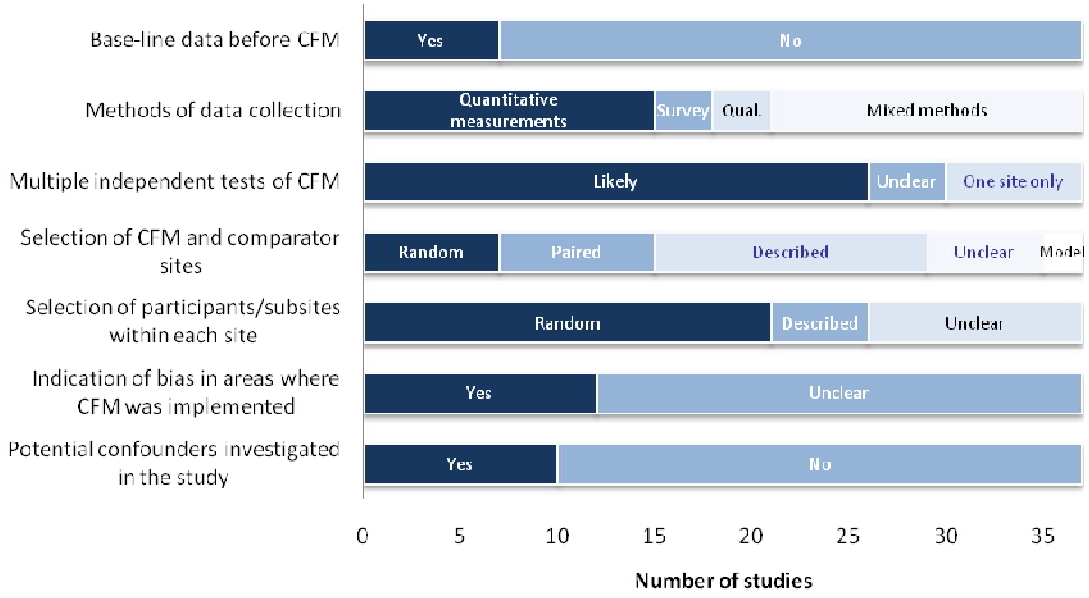


Figure 9. Number of studies using different methodological approaches. More information on each component is given in the text below.

Although most studies tended to investigate several different sites with and without CFM, the exact number of sites with independent managements was not always clear. For instance, several studies investigating multiple study sites (e.g. villages, forests or plantations), each within a number of different 'forest divisions' did not make clear whether each forest was subject to independent management, and therefore could provide independent replicate "tests" of the effects of CFM. Seven studies collected data from only one forest/village with CFM and in another four studies it was not clear whether more than one independent site was studied.

There were two scales of site selection within studies: firstly, selection of forests/villages and, secondly, selection of sub-sites/participants within each forest and village. At the first scale, seven studies selected CFM and comparator forests or villages at random from a wider study area and eight studies selected study sites that could be paired (either because they were in close proximity or matched ecological/sociological variables, or a combination of the two). However, in these cases, the exact method of selection or pairing was usually not detailed and therefore the robustness of these approaches is not clear. Studies pairing adjacent sites did not report the distance between sites, nor did any study discuss or investigate the potential for spill-over (or 'leakage') effects between adjacent sites being compared. Fourteen other studies did not select sites at random or based on matched pairs but 'described' another method of selection, which usually suggested that selection purposively aimed to cover different types of environments. Similarly, at the second scale, although 21 studies reported that participants or sub-sites within the area of each forest or village were selected at random, the method of this selection was generally not detailed. Several studies did not clearly explain selection of either the CFM forest/villages (six studies) or the sub-sites/participants within each forest/village (11 studies).

Only ten studies investigated factors that may confound direct comparison of CFM forests with forests under an alternative management (either as part of an explicit statistical investigation or implicitly based on the data that were presented in the

article). This was assessed on the basis of whether the article presented data on between-site differences (such as in geophysical environmental factors like elevation or in previous forest conditions/past use) apart from the outcomes of interest. Such differences could reflect intrinsic differences in the placement of CFM sites and/or in post-placement activities, or they could simply be due to the method of selecting study sites by the researchers. Three of the studies that were investigating fuelwood collection/consumption accounted for household/village characteristics in their data analysis (Edmonds 2002; Bandyopadhyay and Shyamsundar 2004; Kohlin and Amacher 2005). Three other articles presented data to support the assertion of the authors that their study was comparing sites that were similar in some respects (Gautam and Shivakoti, 2005; Persha and Blomley, 2009; Ali et al. 2007). A further three studies that sampled multiple CFM and comparator sites to investigate differences in forest condition presented data on various variables such as elevation, soil type and slope to investigate covariation between these variables and types of management (Tucker et al. 2007; Sakurai et al. 2004; Nagendra 2007). For instance, Nagendra (2007) found that leasehold forests were on steeper slopes than community and national forests; Tucker et al. (2007) found that common property forest occurred at higher elevations than private forests although there was no difference in slope and soil elements, and Sakurai et al. (2004) compared private and community plantations and found that community plantations were larger, had a higher percentage of gravel in the soil and a higher proportion of formerly grazing land. Kumar (2002) presented demographic data of their sample village in their assessment of forest condition and resource extraction. Overall, twelve studies provided information that was deemed to suggest bias in the types of forests where CFM was implemented. However, this was mostly based on discussion of details in the processes leading to the implementation of CFM in the particular site under investigation. For instance, some studies noted that CFM had been implemented in degraded forests. However, in some cases, a bias in placement could be inferred from the data presented (e.g. Edmonds 2002; Nagendra 2002; Tucker et al. 2007; Sakurai et al. 2004; see also Somanathan et al. 2009). In the remaining studies, no clear information was presented to judge whether there was bias in the types of forests where CFM was implemented. Thus, overall, most studies did not fully consider or account for confounding variables in their investigation of the effect of CFM.

4.2.4 Timescale of studies

Of those studies measuring an aspect of forest condition, 13 did not report the age of the forest management at the time of data collection, in other words, the length of time that CFM had been implemented before assessment. Two studies surveyed recently declared CFMs (Nagendra 2002; Eeden et al. 2006) while the median value of the remaining studies was approximately as eight years (range = 1 – 21; in two of these cases, only ages of the plantations rather than the date of CFM implementation was given) based on the maximum and minimum ages that could be extracted from the article. Because studies investigating forest cover with satellite data incorporated CFM sites over a large area, the ages of CFMs within these studies was variable. The median age of CFM across all these studies was approximately seven years (range = 0 – 25 years) based on the maximum and minimum ages that could be extracted from the article. Similarly, in studies measuring livelihood outcomes, the age of CFM at the time of data collection ranged between 3 and 12 years, or was not clear in two studies.

Only the study of Blomley et al. (2008) analysed data on how the effects of CFM management may change over time following implementation. This suggested a decline in the percentage of cut poles and trees over time following implementation although this trend was not statistically significant.

4.3 Quantitative synthesis/Meta-analysis

In this section, the findings of studies included in the review are synthesized to investigate the overall results emerging on the effect of CFM. However, the reliability of these findings is affected by the methodological quality of the studies, which must be considered in their interpretation. Most studies suffer from problems associated with selection bias and other potential confounders (see section 4.2.3)

4.3.1 Forest cover and condition

Forest cover

For the four studies that investigated change in forest cover before and after the implementation of a CFM programme (Table 2), the trend is mixed: three showed an increase in forest cover over the period assessed (Sreedharan & Dhanapal, 2005; Gautam et al., 2004; Gautam & Webb, 2002), and the last, a slight decrease (Dalle et al., 2006).

Table 2. Percentage forest cover before and after the implementation of community forest management in the four studies that present suitable data (n=4).

Author	Type of CFM	Percentage forest cover[1]		Period of assessment[2]	Geometric rate of change[3]
		Before CFM	After CFM implementation		
Dalle et al. 2006	Community forestry	80	76	21 years	-0.24
Gautam, et al. (2004)	Community forestry	34.8	40	24 years	0.58
Gautam & Webb (2002)	Community forestry	48.3	87.2	14 years	4.32
Sreedharan & Dhanapal (2005)	Joint forest management	47.3	81.4	4 years	6.01

[1] For the Gautam & Webb (2002) study, this is the percentage of 'high forest' in the forested area; where forest 'type' is classified on the basis of crown cover as either degraded land with a crown cover of <10% (called 'scrub') or land with a crown cover of >10% (called 'high forest').

[2] This period of assessment is based on the time period between satellite images and does not necessarily reflect the length of time of CFM implementation.

[3] Following Cote et al. (2005): geometric rate of change, C_{Rg} , = 100 × [1- $(PC_A/PC_B)^{1/d}$], where PC_A and PC_B are the percentage cover after and before CFM implementation respectively; and d is the period between assessments in years. Note: to aid interpretation, the signs have been reversed so that a positive number indicates an increase in forest cover and a negative one a decrease.

When forest cover is compared between areas under CFM and a number of alternative types of forest management, the differences are not pronounced (Table 3). The three studies reporting land cover change show a consistent trend: deforestation is lower under CFM. Nagendra et al. (2008) assessed land cover change over an 11 year period and found lower deforestation and greater afforestation in areas under CFM than the surrounding landscape. Bray et al. (2008) report half the deforestation rate in community forests than in the protected area forest comparator and Duran-Medina et al (2005), an increase in natural forest cover under CFM, with a mean reduction in cover in the protected area comparator sites.

Table 3. Comparison of forest cover and annual deforestation rate between areas under community forest management and alternative management interventions based on the six included studies presenting suitable data (n=4)

Author	Type of CFM	Comparator	Outcome	Mean Non-CFM	Mean CFM	Log response ratio[1]
Gautam & Webb (2002)	Community forestry	Areas without formal CF	Percentage forest cover[2]	79.9	87.2	0.09
Ellis & Porter-Bolland (2008)	Community-based forest management	Protected area	Percentage forest cover	88.5	90.1	0.02
Somanathan et al. (2009)	Local council forest management	State management	Percentage forest cover	97.2 (n=508)	93.2 (n=240)	-0.04
Nagendra et al. (2008)	Community forestry	Mosaic of land uses ("surrounding land")	Percentage deforestation (1989-2000)	8	5	-0.47
			Percentage afforestation (1989-2000)	22	9	0.89
Bray et al. (2008)	Community forestry	Protected area	Annual deforestation rate (%)	-0.327 (n=11)	-0.163 (n=19)	
Duran-Medina et al. (2005)	Community forestry	Protected area	Annual rate of change in 'natural cover' (%)	-0.18 (n=67)	0.14 (n=22)	

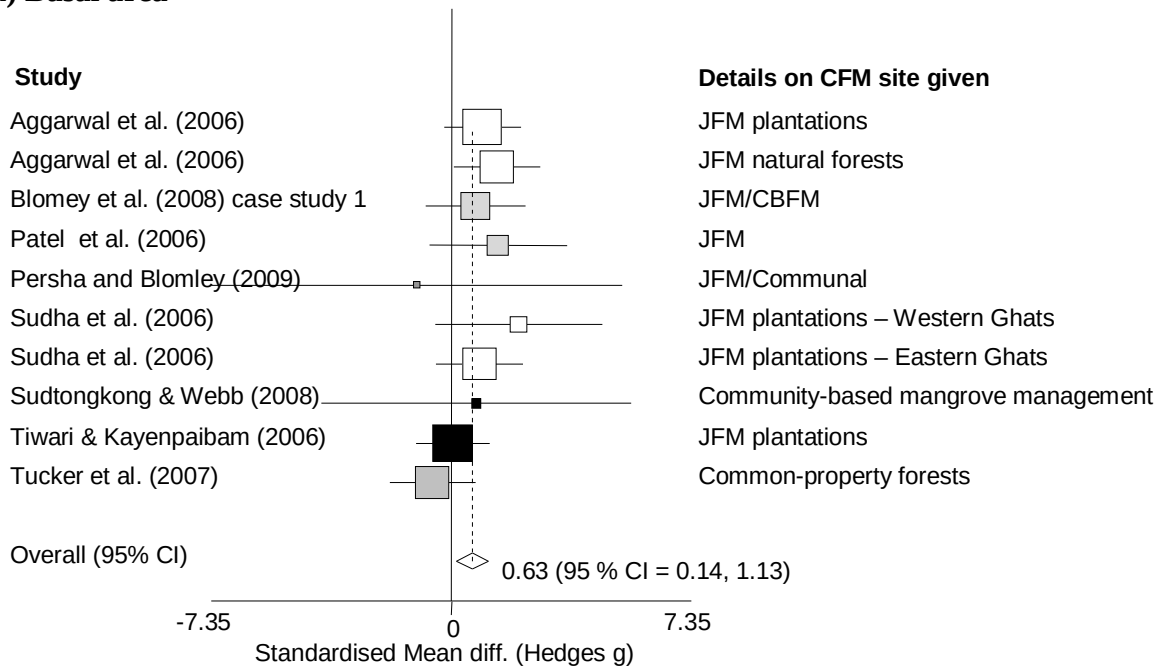
[1]Calculated as the log of the ratio between means before and after CFM to compare the direction and relative size of effect among studies. Thus, a value of 0 indicates no difference in forest cover; a positive value, increased cover in the CFM sites; and a negative value, lower cover in CFM sites.
n = number of forests, which is provided when stated in the article.
[2] For this study, this is the percentage of 'high forest' in the forested area; where forest 'type' is classified on the basis of crown cover as either degraded land with a crown cover of <10% (called 'scrub') or land with a crown cover of >10% (called 'high forest').

Forest condition

Meta-analysis was used to calculate weighted averages of the effect sizes from different studies for different forest condition outcomes. In eight out of the ten effect

sizes, the basal area of trees was greater in forests under CFM than in their comparators (Figure 10 a; Hedges g = 0.633, 95 % CI = 0.140, 1.126). Heterogeneity (variation in effect size among different studies) was not significant (Q = 8.046, df = 9, p = 0.53). However, there was variation in management of the comparator. We

a) Basal area



b) Tree density

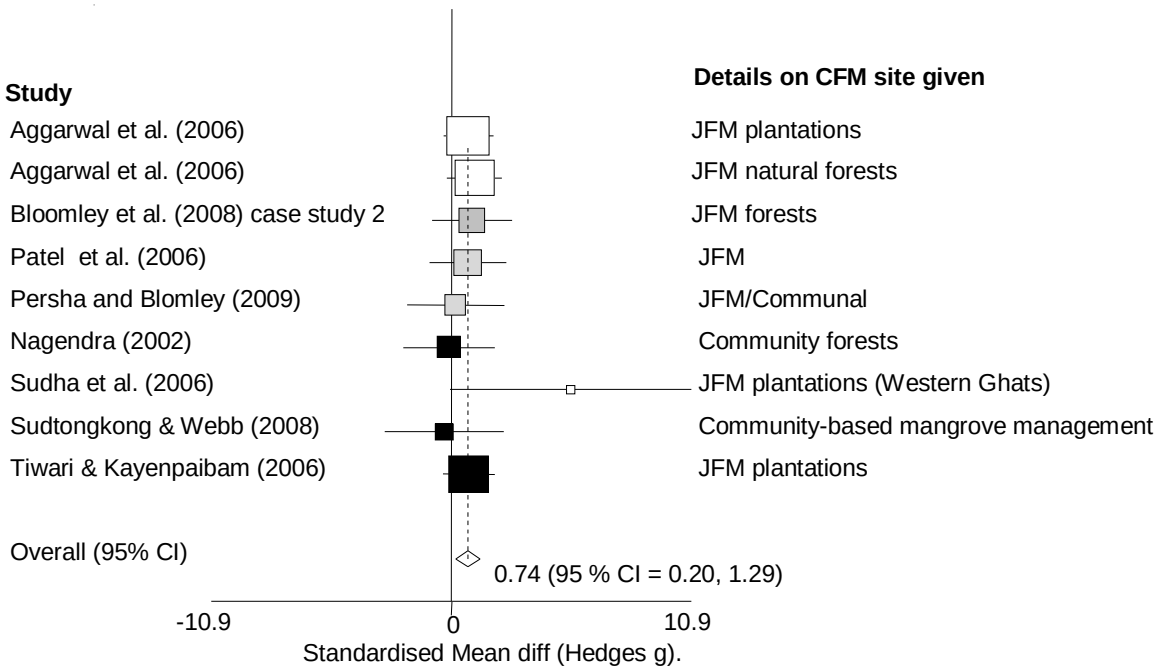


Figure 10. Effect of community forest management on a) basal area and b) density of tree stems. Data represent the effect size (Hedges g) and its 95% confidence interval. The weighted average is indicated as the 'overall' effect. Information is given on the type of CFM and forest where possible. Shading refers to the type of site that the CFM is compared with: black = state or other management; white = no silvicultural management; grey = mixed comparator or no clear characterisation of comparator.

attempted to explore this but noted that detailed information on the management activities in the comparator site was usually not given. Studies comparing a form of CFM with sites with no silvicultural management tended to find larger than average effect sizes (Hedges g = 1.13, 95 % CI = 0.423, 1.830; four effect sizes from two articles). The remaining studies compared CFM with either state management, some other management, or the comparator was not clear or was a mixture; based on these data there was less evidence of a difference (Hedges g = 0.156, 95% CI = -0.536, 0.848). Too few studies were available to tease apart the effects of different comparator managements.

In a second analysis, tree density was greater in seven out of nine cases under CFM (Figure 10 b; Hedges g = 0.745, 95 % CI = 0.197, 1.292) and there was little heterogeneity among studies (Q = 4.606, df = 8, p = 0.799). Studies comparing CFM with no management tended to find a larger effect than the remaining studies, which had various comparators (studies comparing CFM with no silvicultural management: Hedges g = 1.07, 95 % CI = 0.007, 2.125; other studies: Hedges g = 0.549, 95 % CI = -0.177, 1.276) but too few studies were available of different comparator types for rigorous assessment.

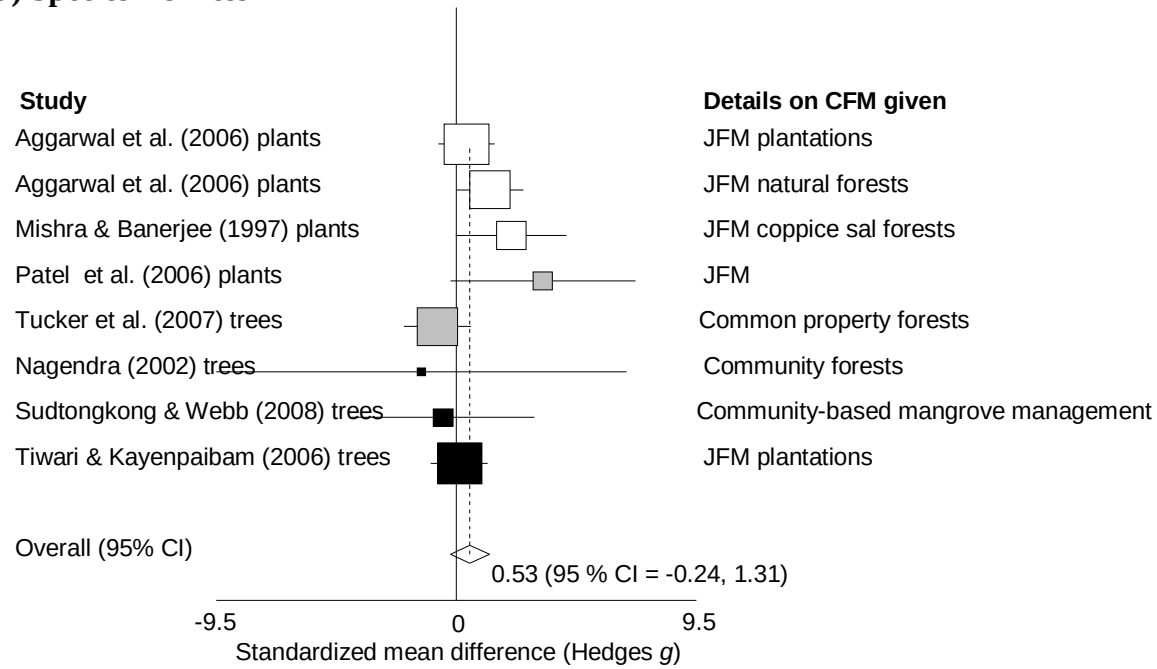
We also investigated effects on species richness and diversity. There was no consistent evidence that CFM affects plant species richness (Figure 11 a; Hedges g = 0.535, 95 % CI = -0.239, 1.308). While there was some variation in effect among studies the amount of heterogeneity did not reach significance (Q = 10.63, df = 7, p = 0.2). Three effect sizes (from two articles) were derived from comparisons with no management (either "preservation plots" or no silvicultural management declared; Hedges g = 1.02, 95 % CI = 0.12, 1.92), which supported a positive effect on richness. The remaining studies were more equivocal (Hedges g = -0.06, 95 % CI = -1.06, 0.945). However, as in previous analysis, the low number of studies limits exploration of the effect of different comparator managements.

Similarly, there was very little evidence of any consistent effect on plant species diversity (Figure 11 b; Hedges g = -0.046, 95 % CI = -0.819, 0.727) and insignificant heterogeneity among studies (Q = 3.73, df = 4, p = 0.4). Three of the five effect sizes compared CFM management with another form of management (state, national forest or plantation; Hedges g = -0.56, 95 % CI = -1.52, 0.40) and no difference was evident based on this subset.

Across all outcomes, there was no evidence of publication bias as assessed with a funnel plot and Egger's test but the ability to detect bias is limited given the small number of separate studies within each meta-analysis.

Some studies also presented data on the user perceptions of forest condition but because there are 12 studies that directly measured forest condition we chose not to review these reports of less-quantitative indirect information.

a) Species richness



b) Species diversity

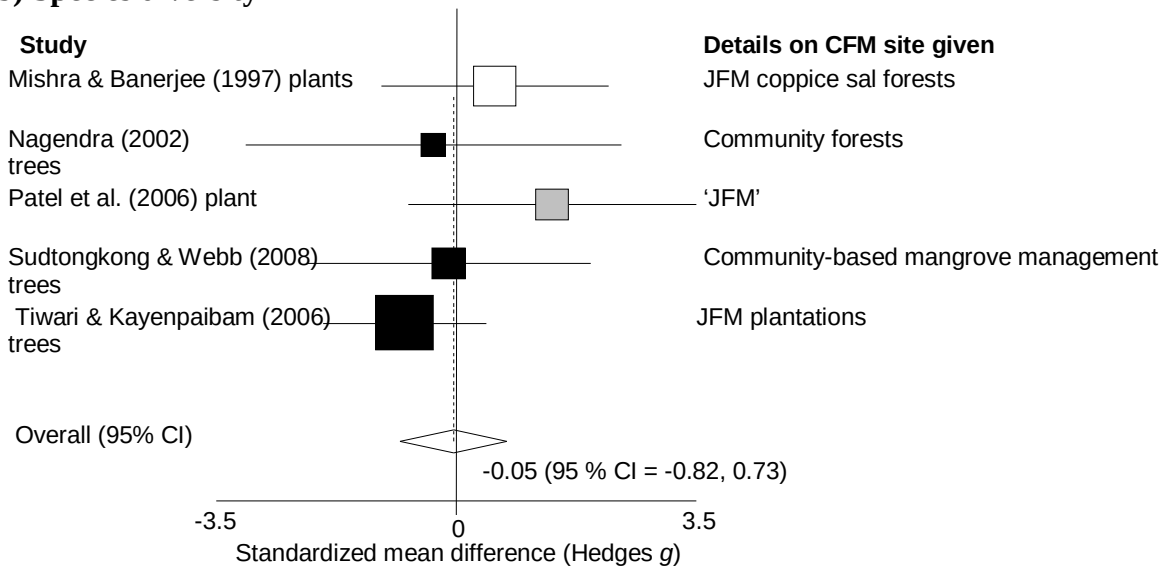


Figure 11. Effect of community forest management on a) number of species (trees or all plants as stated by the authors) and b) species diversity (Shannon-Weaver index; trees or all plants as stated by the authors). Data represents the effect size (Hedges g) and its 95% confidence interval. The weighted average is indicated as the 'overall' effect. Information is given on the type of CFM and forest where possible. Shading refers to the type of site that CFM is compared with: black = state or other management; white = no silvicultural management; grey = mixed comparator or no clear characterisation of comparator.

4.3.2 Resource extraction

Two resource-extraction outcomes were analysed: stem cutting and fuelwood collection. The six studies reporting data on stem cutting found that this tended to be lower in forests under CFM but the confidence intervals of the overall effect slightly overlapped zero (Hedges g = -1.06, 95% CI = -2.195, 0.075; Fig 12). However, there was some indication of variation in effect size among studies, which suggests that other factors affected this outcome (Q = 12.964, df = 5, p = 0.02). There was no evidence of publication bias as assessed with a funnel plot and Egger's test but the ability to detect bias is limited given the small number of separate studies within each meta-analysis. The four studies reporting on fuelwood extraction are summarised in Table 4.

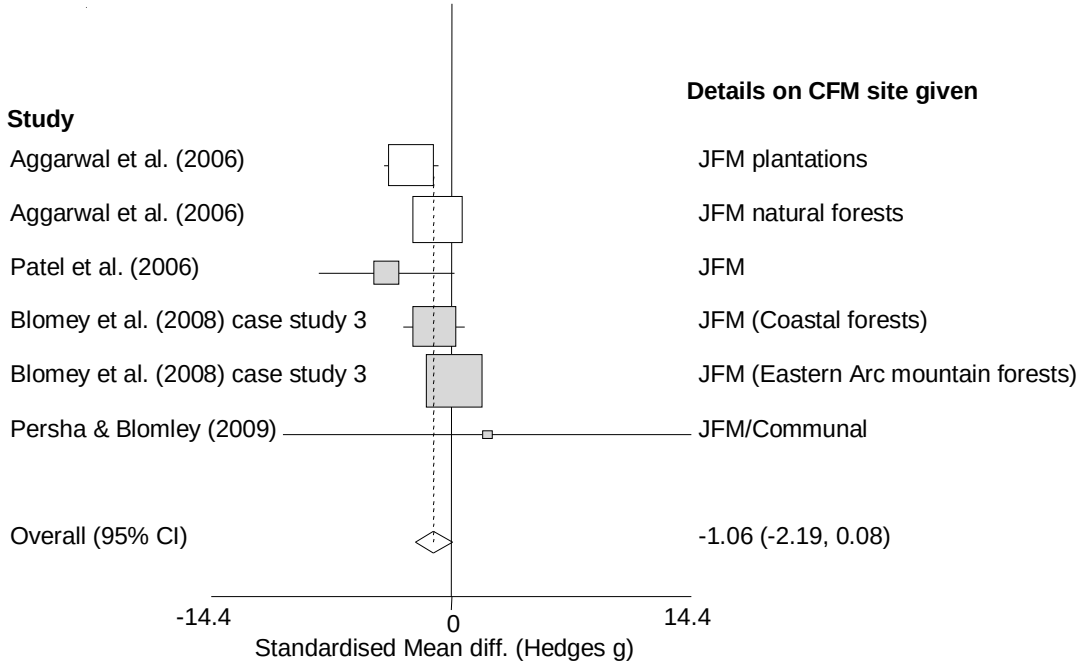


Figure 12 Effect of community forest management on the number, density or percentage of cut stems. Information is given on the type of CFM and forest where possible. Shading refers to the type of site CFM is compared with: white = no silvicultural management; grey = mixed comparator or no clear characterisation of comparator.

4.3.3 Livelihoods

Few studies gave quantitative information on livelihood outcomes. Those that did usually presented very different types of data which were not directly comparable between studies. We were not able, therefore, to undertake meta-analysis of livelihood outcomes data and were confined to providing a narrative synthesis. This means that the synthesis on livelihoods is less concise than in previous sections.

Table 4. Comparison of fuelwood extraction in forests with and without community forest management in the studies presenting suitable data (number of studies = 4).

Author	Type of CFM	Comparator	Outcome	Mean Non-CFM	Mean CFM	Ln RR[1]
Adhikari et al. (2007)	Community forestry	Before/after	Total fuelwood collection (kg)	29,429 (n=8)	31,395 (n=8)	0.06
Bandyopadhyay & Priya (2004)	Community forestry	Villages without community forestry	Average annual fuelwood collection (kg per household)	753 (n=482)	955 (n=42)	0.24
Edmonds (2002)	Community forestry	Villages without community forestry	Average household fuelwood collection (bhari/headloads per year)	114 (n=?)	98 (n=?)	-0.15
Gupta et al. (2004)	Participatory forest management	Before/after	Average annual quintals of fuelwood collected per family	28 (n=2)	13 (n=2)	-0.76

N = number of forests/villages depending on author presentation
[1]Log Response Ratio

Tables 5 – 10 contain a summary of livelihood outcomes from included studies, presented within DFID's 'capital assets' framework (DFID 2000). In Table 5, Ali et al (2007a), present data from Pakistan showing no difference in the number of income sources available to participatory forest management (PFM) and non-PFM households and only small differences in primary source of income (with slightly more income from forest sources and small business activities, but less income from agriculture in PFM sites). For both PFM and comparator sites, the single largest sources of income were from "labour", and qualitative findings suggest that this is mostly from sources outside the village locality. This study lacks baseline information and does not provide convincing evidence of any meaningful impact of PFM on income over the five years studied. In contrast Gupta et al. (2004) recorded that PFM projects in two case-study villages in India led to forest-based occupations becoming a new (but relatively small) source of income (Table 5). There was also an increase in the percentage of income from "labour" in one village, after the introduction of PFM. This study also suggests (Table 6) that levels of household income increased after the introduction of PFM although the extent to which this is due to new forest-based sources is not clear. The length of time studied is also unclear, projects having been running for "at least three years" in each site.

Niesenbaum et al (2005) present data suggestive of an increase in forest-related income levels over a five-year period since project initiation in Guatemala. However, this study uses baseline data collected by participant recall as the comparator and therefore lacks reliability. Kassa et al. (2009), in a modelling study using empirical

data from an Ethiopian project, build PFM and non-PFM scenarios and predict trends in annual household income over a 30-year period. The model predicts income to increase more in non-PFM compared with PFM households in the medium (up to 7.5 years) term but this predicted trend then reverses over a longer period (7.5-30 years). However, since this is a model, these findings cannot reliably be used as primary evidence. Collectively, and taking the methodological robustness of studies into consideration, these studies do not provide convincing evidence that PFM has any significant impact on income levels over the medium time periods they cover. There were no data available from a longer time period to substantiate the predictions by Kassa el al. (2009).

Table 5. Impact of community forest management on livelihood outcomes: financial capital (income sources) Number of studies = 2.

Author	Type of PFM	Comparator	Outcome		Mean non-CFM	Mean CFM
Ali et al. (2007a)[1]	Participatory forest management	Traditional management	Two or more household cash income sources		52.5% (n=4)	54.5% (n=4)
Ali et al. (2007a)[1]	Participatory forest management	Traditional management	Frequency of different primary household income sources	*Agriculture*	17%	9.5%
				Labour /salary	40%	41%
				Livestock	2%	2.5%
				Small business	7.5%	16.5%
				Forest	0.5%	3.5%
				Other	32.5% (n=4)	27.5% (n=4)
Gupta et al. (2004)	Participatory forest management	Before/after comparison	Frequency of different household income sources	*Agriculture*	25[2] 26	20 27
				Labour	5 5	7 17
				Service	16 14	15 15
				Animal husbandry	10 27	10 27
				Forest	0	9 18
				Other	0.1 (n=2)	3 (n=2)

N = number of forests/villages as reported by the author

[1] Additional data available in article: how money was stored, sources of loans.

[2] In studies presenting only two data points, we present each value rather than calculating an average.

Table 6. Impact of community forest management on livelihood outcomes: financial capital (levels of income). Number of studies = 5.

Author	*Type of CFM*	*Comparator*	*Outcome*	*Mean Non-CFM*	*Mean CFM*
Maharjan et al. (2009)	Community forestry	No community forestry or development project	Net annual per capita income (NRupees)	*Well-being category*	
				Rich 44017 23801	21944
				Middle 22409 39409	16117
				Poor 12135 18091	11941
				Ultra-poor 13047 12195	10499
				(n=2)	(n=8 except ultra-poor=4)
Maharjan et al. (2009)	Community forestry	No community forestry or development project Data in italics in 3rd data column are for 'before' implementation of CFM in CFM sites	Proportion (%) of net annual income from forest related activities		*Before* *After*
				Rich 5 36[1]	*21.1* 5.9
				Middle 7 35	*26.9* 15.0
				Poor 13 46	*32.5* 15.9
				Ultra-poor 7 44	*28.8* 25.5
				(n=2)	(n=8 except ultra-poor=4)
Niesenbaum et al. (2005)[2]	Community forestry	Before and after (5 years)	Average income per person from participation in forestry-related activities (Guatemalan Queztales)	*Income-generating activity* *Before*	*After*
				CFM 400	800
				NTFP 150	1420
				Furniture making 200	1650
				Ecotourism 0	125
				(n=?)	(n=?)
Gupta et al., (2004)	Participatory forest management	Before and after (3 years)	Change in family income (Rupees) – number of families at each income change level	*Annual income* *Before*	*After*
				<12000 1 7	0 1
				12-24000 6 9	0 12

				24-36000	2 8	6 4
				36000+	15 3 (n=2)	18 10 (n=2)
Vyamana (2009)	Joint forest management	Before and after (5-10 yrs)	Average annual household income from PFM forest(Tanzanian Shillings)	*Wellbeing category*	*Before*	*After*
				Very rich	0	0
				Rich	9200 48000	0 57900
				Poor	15310 27484	2653 65066
				Very poor	0 38541	0 59571
					(n=1 or 2)	(n=1 or 2)
Vyamana (2009)	Community-based forest management	Before and after (5-10 yrs)	Average annual household income from PFM forest (Tanzanian Shillings)	*Wellbeing category*	*Before*	*After*
				Very rich	68300 50049	61313 56561
				Rich	1607495 28000	3235386 32200
				Poor	50310 33174	62013 50530
				Very poor	46205 16800	70235 27200
					(n=2)	(n=2)
Kassa et al. (2009)	Participatory forest management	No PFM	Predicted annual household income over 30 years[3]	*In first 7.5 years: no PFM > PFM* *7.5 years to 30 years PFM >no PFM*		

[1]In studies presenting only two data points, we present each value rather than calculating an average.
[2]Additional data available in article: % participation in the forestry-related income generating activities
[3] This model was based on empirically collected data

Maharjan et al. (2009) studying PFM projects in Nepal and Vyamana (2009) in Tanzania, explored impacts on equality of income. Maharjan et al. (2009) estimated net annual income for four "well-being" categories (indicating economic status), comparing community forestry (CF) and non-CF sites. No baseline data were collected, rather participants recalled the situation prior to CF and described the direction of change, which limits the reliability of the estimates. Therefore we only present quantitative data for the study year (2006) with only a qualitative indication of the trend since project initiation some 3-10 years previously. These data (Table 6) suggest that for all well-being categories, the non-CF communities had, on average, higher net annual income per capita than the CF communities. The authors suggest that these arose from increased "remittances" and wage labour rather than increases in income from forest-related sources. This is somewhat supported by data on the proportion of the net per-capita income which comes from forest-related activities (Table 6) which suggest that forest-related cash income may have decreased with CF in all except the ultra-poor households. However reported data for the two non-CF communities vary greatly with, for each well-being category, one average being below the CF average and the other, well above it. There were no baseline data for non-CF controls so there is no way of knowing if they experienced similar decreases over the same period, but in 2006 the average forest related incomes in households in the two non-CF communities were higher than the average in CF households in all except the ultra-poor category. Forest-related incomes were derived both from community forestry and from other, non-CF forests and the proportion of net annual income which derived from community forestry varied across household income categories, with a mean of 4.6% for rich and 6.5% for middle-income households compared with 9.1% for both the poor and ultra-poor. This suggests a greater dependency on community forestry income amongst the poorest but the percentages are still small, and without information on the variance in the estimates of the means it is not possible to interpret whether any differences presented are significant. This latter limitation is not confined to just this study.

In Tanzania, Vyamana (2009) studied two types of PFM: JFM and community-based forest management (CBFM) In this study, subjects were classified differently to Maharjan et al. (2009), which limits direct comparison between the two studies, but Vyamanas' data show that change in income from PFM forest (after the introduction of PFM) varied within wellbeing categories between the two types of PFM studied (Table 6). For the JFM type there was no clear trend with conflicting findings between the two communities studied within each well-being category, whereaswith the CBFM type, the findings were more consistent in that (with the exception of the very rich group where there was little difference) all well-being groups experienced an increase in forest-related income. These two studies therefore highlight the need to understand how benefits from PFM activity might be distributed within PFM communities. Vyamana (2009) only showed data for four of the eight studied communities which were actively using their PFM forest. This represents a potential bias in the results as data from the other four PFM communities included in the study were not reported because either they were using alternative forest, reportedly to avoid the restrictions placed on use of JFM forests, or (for the CBFM sites) obtained their forest products from nearby plantations and natural forests. This illustrates the point made by several of the studies that restrictions imposed by PFM rules can, in some cases, reduce the opportunities for income generation from forest and this impact is likely to be greatest for those without other income sources, for example those without privately owned forest or who live in areas with no other accessible

forest. It also illustrates the high potential for leakage of forest exploitation activities from areas where CFM has been initiated into other local forests.

Compared with financial capital, there were fewer data on social capital outcomes presented in the included studies (Table 7). Sun (2007) asked participants to provide a score (based on recall) from 1 to 10, for various indicators, for a baseline (1995, 1998 or 2001 as appropriate for each study site) and compared these with 2006 after the initiation of the community-based natural resources management (CBNRM), when the survey took place. A composite score of indicators including trust, mutual help, networking and collective activities was then constructed. These suggest a greater increase in score since baseline, in CBNRM communities, compared with one of the two control communities, but the differences are small and, given the nature of their derivation, have limited reliability. Ali et al. (2007b) reported that perception of both 'trust' and 'relationship' (good) were greater in a PFM community than in a traditional management (control) community only for the forest department and union council but not for police, courts and elders (Table 7). However, the lack of baseline makes it difficult to draw firm conclusions from this study. Maharjan et al. (2009) allude to the difficulty of assessing social capital and, although they do present some data on village Forest User Group committee composition, there are no comparator data. Vyamana (2009) investigated composition of village Natural Resource Committees (NRCs) finding that the rich disproportionally dominated the NRCs in JFM communities whereas the poor dominated them in CBFM and control communities. In the control communities, this was reported to be a reflection of the local demography, whereas in the CBFM community NRCs this dominance by the poor was disproportionately high. Only the CBFM community NRCs included the very poor.

Table 7. Impact of community forest management on livelihood outcomes: social capital. Number of studies = 3.

Author	Type of CFM	Comparator	Outcome	Mean Non-CFM	Mean CFM	
Ali et al. (2007b)	Participatory forest management	Traditional management	Mean score - trust and relationship to state institutions	*Relationship:* *Forest Dept.* 1.96 *Police* 2.13 *Courts* 2.29 *Jirga (Elders)* 3.57 *Union Council* 2.98 *Trust:* *Forest Dept.* 1.60 *Police* 1.96 *Courts* 2.08 *Jirga (Elders)* 3.38 *Union Council* 2.79 (n=4)	 2.72 2.13 2.12 3.58 3.28 2.44 1.95 2.21 3.47 3.11 (n=4)	
Sun (2007)	Community-based natural resource management	Not CBNRM (traditional practices) Before/after	Mean social capital score	*Before/After* 5.47/6.21 5.09/5.14[1] (n=2)	*Before/After* 5.49/6.23 (n=6)	
Vyamana (2009)	PFM (JFM and CBFM)	No PFM	Composition of village Natural Resource Committees by well-being category (% of general population in this category)	*Wellbeing category* *Very rich* 4 (0.6) *Rich* 17 (5.4) *Poor* 70 (73.6) *Very poor* 0 (20.4) (n=2) (n=2)	JFM 4 (2.3) 57 (9.2) 30 (62.4) 0 (26.1) (n=2) (n=2)	CBFM 3 (9.9) 19 (24.2) 61 (36.1) 10 (29.8) (n=3) (n=3)

[1] in studies presenting only two data points, we present each value rather than calculating an average.

Of the included studies, only Sun (2007) provides data relating directly to human capital (Table 8). This is constructed in the same way as for social capital; combining indicators of health, education level, technical skills and labour availability in the family. Again, mean scores show only small differences between baseline and the year of the study (2006) although the difference was slightly higher for the CBNRM communities than the two control communities. Data on fuel wood collection from Kohlin et al. (2005) suggest that individuals in villages without a community forest spend more time collecting fuel from alternative forest sources and that total time spent on collection was lower for those communities able to collect from a community forest.

Table 8. Impact of community forest management on livelihood outcomes: human capital. Number of studies = 2.

Author	Type of CFM	Comparator	Outcome	Mean Non-CFM	Mean CFM
Kohlin et al. (2005)	Community forest (but separate 'natural' forest also available)	No community forest (only 'natural' forest available)	Time spent (hours per week) in fuelwood collection	Collection from natural forest 23.6 (sd = 39.7) (n=248)	Collection from natural forest 15.6 (sd = 2.32) (n=494) Collection from community forest 4.7 (sd =4.6) (n=494)
Sun (2007)	Community-based natural resource management	Not CBNRM (traditional practices) Before/after	Mean human capital score	*Before/After* 5.33/5.54[1] 5.92/6.33 (n=2)	*Before/After* 5.77/6.33 (n=6)

[1] in studies presenting only two data points, we present each value rather than calculating an average.

Physical capital outcomes were reported in three of the included studies (Table 9). The composite score of Sun (2007) included indicators of road and house construction, work on irrigation and drinking water facilities, production tools, fuel energy, communication and markets. As with the other 'capital assets' reported in this study, there were increases in scores since the baseline in both the CBNRM and control sites but the increases were slightly greater in the CBNRM communities than the two control communities. Gupta et al. (2004) reported that the number of families collecting wood as a source of fuel in one of their two study sites decreased after introduction of PFM whereas use of kerosene increased. Vyamana (2009) presented data on three indicators of community physical capital, demonstrating marginally more instances of improvements in CBFM communities than in JFM communities, with no improvement in the two control communities, suggesting that this was due to differences in income-generating opportunities.

Table 9. Impact of community forest management on livelihood outcomes: physical capital. Number of studies = 3.

Author	Type of CFM	Comparator	Outcome	Mean Non-CFM	Mean CFM
Sun (2007)	Community-based natural resource management	Not CBNRM (traditional practices) Before/after	Mean physical capital score	*Before/After* 3.83/5.11[1] 4.55/5.7 (n=2)	*Before/After* 4.04/6.38 (n=6)
Gupta et al. (2004)	Participatory forest management	Before and after (3 yrs)	Sources of fuel (number of families using each source)	*Wood* 20 27 *Dung* 3 1 *Kerosene* 12 16 *Agri-waste* 1 *Biogas* - *LPG* 6 1 (n=2)	16 27 4 1 19 16 1 10 4 15 10 (n=2)
Vyamana (2009)	Participatory forest management (Joint forest management and Community based forest management)	No PFM Data presented for before/after (5-10 yrs) initiation of PFM	Proportion of communities in which developments had taken place	*Road building* 0/2 *School building* 0/2 *Tractor repair* 0/2	0/4 JFM 0/3 CFM 2/4 JFM 2/3 CFM 0/4 JFM 1/3 CFM

[1] in studies presenting only two data points, we present each value rather than calculating an average.

The final group of studies which present livelihood related data (Table 10) are those that conducted cost-benefit analyses, presenting net present values (NPV) over various periods and for various discount rates. Calderon et al. (2006) studied CFM in the Philippines and Kumar (2002) studied JFM in India, both collecting data from actual PFM project sites. Grundy et al. (2000), working in Zimbabwe, used data from one non-PFM site and estimated NPV for model-constructed scenarios of co-management with forest dwellers. The former two studies produced lower NPV for PFM than non-PFM whereas the latter study produced very similar NPV for both scenarios. Kumar (2002) also investigated equality of benefit, estimating net benefit across different land-owning classes; these data (not included in Table 10) show the decrease in net benefits over time from JFM forests to be greater for landless and marginal farmers (45–50%) than for those with large farms (6%). As for income,

Kumar (2002) suggests that restrictions placed by JFM impact most on the poorest, reducing the benefits they receive from forest resources.

Table 10. Studies presenting cost-benefit analyses of community forest management. Number of studies=3.

Author	Type of CFM	Comparator	Outcome	Mean Non-CFM	Mean CFM
Calderon et al. (2006)	Community-based forest management	Commercial management (IFM)	Estimated net present value (US $ per ha)	368 (n=3)	11 (n=3)
Kumar (2002)	Joint-forest management	Government management	Predicted net benefit of management (Rupees per household) averaged across different landholding classes[1] after 40 years	112440 (n=5)	72367 (n=3)
Grundy et al. (2000)	Co-management with forest dwellers included (model constructed scenario)	"Status quo" state management (model-constructed scenario)	Predicted total net present value of benefits (Zimbabwe$ million) over 60 years using 3 discount rates	*Discount rate* 1% 955 6% 329 15% 142 (n=1)	 1035 349 148 (n=1)

[1]presented in the article separately for different landholding classes; here we present the average across classes

5. Discussion

5.1 Evidence of effectiveness

Quantitative syntheses of data on forest condition suggest that, in a majority of the studies, areas with CFM have higher forest cover, tree basal area and tree stem density. This may indicate that CFM has had a positive impact on forest condition during the lifetime of current CFM arrangements but the study designs do not eliminate the possibility that these differences were present at baseline (before CFM was implemented), i.e. due to bias in the selection of locations for implementation of CFM. The type of management in the comparator site is variable among studies but the detail of management activities was not usually described. Thus, despite the fact that the effect of CFM would be expected to vary with the comparator management, this could not be rigorously explored. Given that CFM can take a number of different forms, understanding the elements that influence its success is crucial for successful implementation. However, the low number of studies available means that it is not possible to tease apart which attributes of the CFM being implemented were the most important for its impact on forest condition. Additionally, and importantly, the indicators that were measured in the reviewed studies are unlikely to be correlated with all components of forest condition and ecosystem services. Indeed, the benefit of any effects observed on tree stem density alone will also depend on tree size and age. No evidence was found of an impact of CFM on plant species richness or diversity. Regarding resource extraction, the data on number of cut stems suggest a tendency towards fewer cut stems in forests with CFM than without, but this is based on only four studies. This result could be indicative of the effectiveness of implementation of the management rules formed by the community institutions. Similarly, a small number of studies presented data on fuelwood collection but their findings were not consistent.

The evidence for the impact of CFM on local livelihoods was even less conclusive. Only 12 studies met the inclusion criteria to be retained in the review and these reported highly variable outcomes. Most data are on financial capital but these show no consistent evidence that PFM results in increased cash income. However, there are important messages regarding the distribution of financial benefits within PFM communities (Table 6).

5.2 Reasons for variation in effectiveness

Many ‘reasons for heterogeneity’ or ‘effect modifiers’ were discussed within articles included in the review (Figure 13). Note that in many cases the discussion by authors was not backed-up with data that would allow investigation of the effect.

Consequently, no formal analysis of the significance of these variables was possible.

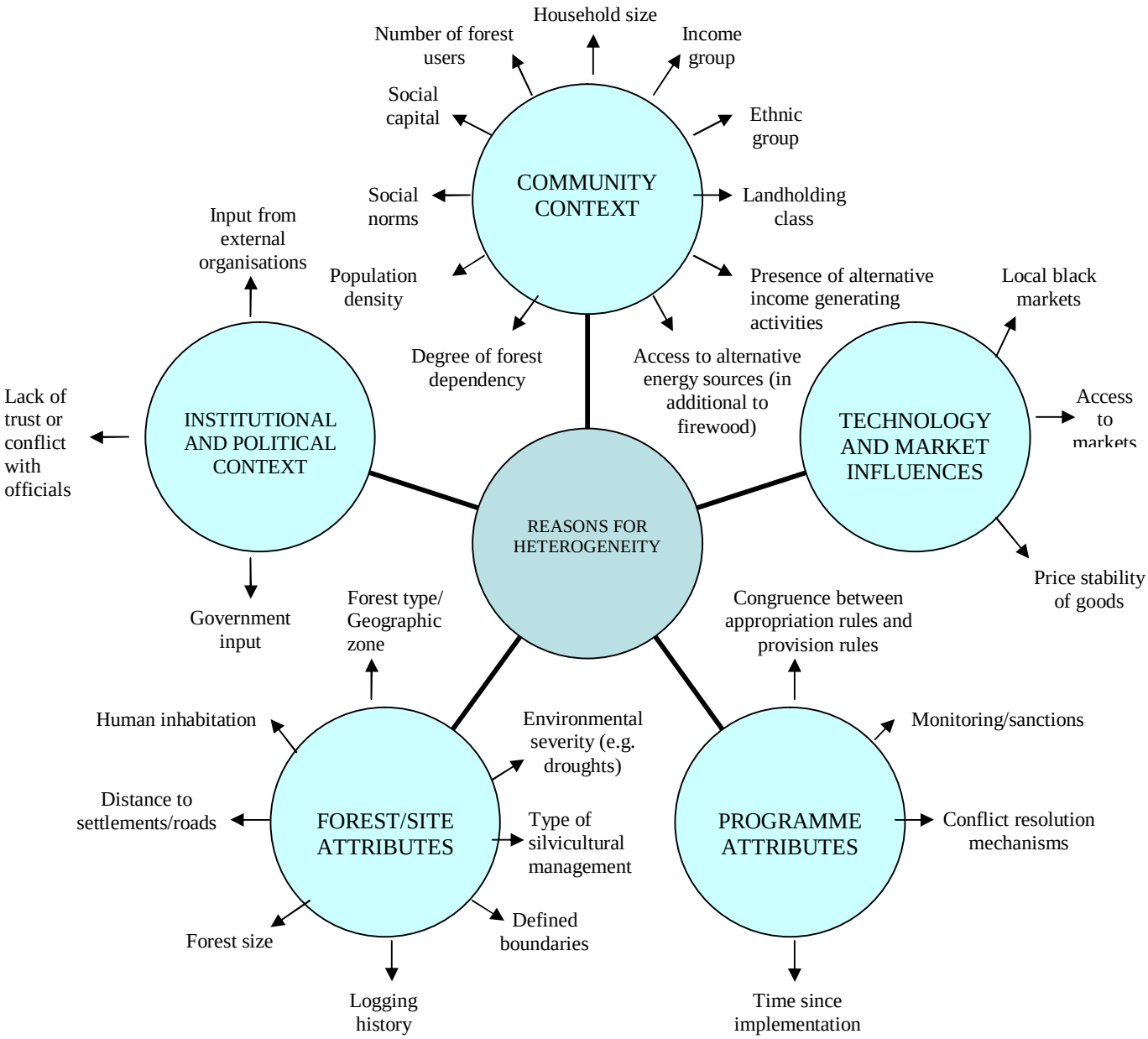


Figure 13. Potential reasons for variation in community forest management impacts discussed by the included studies.

5.3 Review limitations

5.3.1 Study designs

The review is limited by the quality of the methodological designs used in most studies. Many studies were not included due to the lack of a comparator that would enable any change in outcome to be attributed to the treatment (CFM). All the studies

included fall short of a full BACI (before/after and control/intervention site comparison) design and very few had a sufficient sample size of independent CFM and non-CFM forests/communities to reduce error and account for bias to levels reasonable for the accurate interpretation of the differences in outcome between treatment and comparator. This means that even though differences may have been found by individual studies, attributing these differences to a general effect of CFM is problematic. Given that randomisation of allocation of CFM between locations/forests is unlikely to be carried out, it becomes even more important for studies to investigate base-line differences and other potentially confounding variables between CFM and non-CFM sites. Potential confounders should be accounted for in the data analysis (e.g. using propensity-score matching methods) before any causal inference of the effects of CFM can be attempted. The selection of the appropriate covariates requires debate and explicit investigation. However, in the studies included in this review, commonly measured variables were distance of village to nearest forest or nearest road, forest elevation, steepness of slope and soil quality of the forest.

Only a minority of the studies were based on a before-after CFM project intervention comparison, or contained any other useful baseline data on the situation before CFM. Information was not usually provided about the criteria used to decide which forests/communities would receive a project intervention to promote CFM and which not. Bias could be in either direction. A few studies noted and/or provided evidence that CFM was implemented in an area because either the forest was degraded; was suffering from deforestation or was generally less productive than lands with other managements. For instance, Maharjan (1998) describes how local people, having recognised the degradation of their community forest and its implication for their subsistence, approached the District Forest Office in order to establish a Forest User Group. In the case of this direction of selection bias, any positive differences in forest condition that are estimated after implementation between CFM and the comparator site underestimate the total effect of CFM. Whereas in opposite cases CFM may have been preferably implemented in the forests that were in better condition; we found little evidence of this but given that bias was rarely discussed or investigated, this cannot be ruled out for some regions/countries. Positive bias is even more likely for social factors, with a probability that communities with stronger existing institutions (or greater social capital) would be selected for CFM. Therefore, whether or not CFM has been a 'bottom-up' community-led innovation or come about through intervention by government or other agencies, it is unlikely that its distribution between forests/communities is independent of the previous situation there. Bias in post-hoc comparisons between CFM and non-CFM cases is therefore inevitable; however the direction of that bias may vary.

Tropical forest policy, e.g. with respect to project intervention of payment for ecosystem services such as carbon storage, has been increasingly concerned with the potential problem of 'leakage', i.e. that a project intervention to reduce a form of forest exploitation may successfully achieve this in the target area but simply displace this exploitation to an adjacent area with no net benefit. This phenomenon is a particular risk for many of the reviewed studies comparing CFM with non-CFM forests, since so little information is provided about how independent the compared sites are; and even the geographic distance between the different sites being studied. Close proximity of study sites may be beneficial in terms of the matching of environmental variables, but risky in terms of the likelihood that the results have been distorted by 'leakage'.

Various additional factors may vary between the sites with and without CFM that may confound any direct comparison, however only a few studies have attempted to investigate and/or account for this.

5.3.2 Interpretation of outcomes measures

The reviewed studies measured a broad range of different outcome measures which we classified between forest condition and livelihood 'pools'. Our meta-analysis on forest condition focused on tree stem density, basal area, and plant species richness and diversity as these were the most commonly reported outcome measures. However, particularly in the case of tree stem density, interpretation of any changes as an indicator of CFM success (with respect to carbon sequestration) will depend on other variables such as tree size or species (Chave et al. 2005; Newton, 2007; Gibbs et al. 2007). Thus, effects of CFM on tree stem density alone cannot be easily interpreted as being positive or negative as they are also a reflection of stand development and the frequency of disturbances. In addition, some studies were measuring plantations rather than mature forests.

Inferring effects of changes in tree basal area on (above-ground) carbon sequestration may be possible as basal area indicates wood volume, but other variables such as tree height will also affect this relationship (Philip, 1994). Extrapolation to carbon sequestration will be even more subject to error if below-ground storage is included. None of the studies included in the review attempted to estimate total carbon stocks.

Similarly, extrapolating from the few outcome measures in most of the reviewed studies to the impact of CFM on whole livelihoods must be done with great caution. For instance, it is not clear how a change in the source and number of income sources impact on livelihoods.

Consensus on, and standard measurement of, indicators of the success of CFM would greatly aid synthesis on its effectiveness. This is, at present, lacking from the body of empirical studies included in this review.

5.3.3 Diversity of comparators

There is no consensus on the appropriate comparators for a community-managed forest and the use of a varied set of comparators in the studies included in this review increases the difficulty of interpreting differences in outcome. For instance, differences in the effects of a CFM plantation versus a forest with no silvicultural interventions may be more a reflection of the type of forest than of CFM per se. The direction of the effect on the outcome would be expected to differ between cases where the comparator is a formal protected area, open access exploitation or private management. Too few studies were available to allow any contrast in the effect size between different comparator managements to be investigated.

5.3.4 Study reporting

In some cases the incorporation of study data in a synthesis and interpretation of heterogeneity in outcome is inhibited by lack of reporting of key variables and aspects of methodology. For example, some studies presented simple means (with no measure

of variance) for the treatment and comparator and many failed to give sufficient information on the type of intervention and the nature of comparators.

5.3.5 Geographical coverage

It is probable that the socio-economic and cultural contexts of the location in which CFM takes place would have an influence on its effectiveness. It is a limitation for global interpretation, therefore, that most studies included in the review have taken place in just two neighbouring countries (India and Nepal).

5.3.6 Study timescale

The length of time from CFM implementation (or at least its formal notification) to data collection varies between studies from less than one year to more than 15 years. Effects of CFM management are likely to be realised only after a period of time but it is not clear how long this should be (cf. Blomley et al. 2008). Thus, effects sizes in studies measuring sites with more recent intervention may more likely represent selection bias rather than the effect of CFM. Future meta-analysis could aim to examine how the effect size varies with the study timescale. The environmental and socio-economic impacts of changes in natural resource management often have a very long timescale, especially with long-lived organisms such as trees. Whilst sustainability may be a widely held goal, it is very difficult to judge whether it has been achieved for forest resource management until many decades have past. Achievement of such sustainability may also occur at the expense of the short-term rate of resource exploitation, meaning that the effect on livelihoods may change depending on whether short-, medium- of long-term outcomes are considered. Therefore, the short duration of the majority of studies reviewed is a severe limitation in the value of their results for assessing the longer-term effectiveness of CFM.

6. Reviewers' Conclusions and Implications for policy and research

The available evidence suggests that there are some benefits of CFM in terms of forest condition. However, only a limited number of components of forest condition have been measured and their reliability as robust indicators of broader aspects of forest condition and the full range of ecosystem services, and their resistance to manipulation for self interest, need to be tested. The outcome of the review suggests that some evidence exists for global environmental benefit of CFM through increase in carbon sequestration on the assumption that higher levels of tree basal area indicate a higher level of ecosystem above-ground carbon storage. However, there is no evidence of benefit to biodiversity conservation. This finding should be considered in the light of the short timescale of measurement versus the low likelihood of significant changes in species composition over such timescales, especially in countries such as India and Nepal where there is a high level of forest fragmentation. There is insufficient evidence to conclude what effect CFM has on local livelihoods.

There is a strong need for institutions making costly project interventions to critically assess the attribution of any positive outcomes achieved (i.e. whether they are due to the project intervention or would have occurred anyway). For this reason, much better information needs to be recorded in studies of CFM about the selection of

communities/forests to receive CFM project intervention. If they have been selected as communities with the most degraded forests that are currently providing low levels of local income, then the occurrence of subsequent forest condition and local incomes that are comparable with non-selected forests may represent a very successful project outcome. However, if a CFM project is located in a community that already has higher levels of community participation in forest management, an assessment which indicates a moderately higher level of forest condition and local income than a non-CFM community may not indicate any additional project benefit at all.

In addition, while assessment of outcome may be required even in short-duration projects, great care is needed in its interpretation: short-term success may not predict longer-term benefit, whereas even if there is a lack of short-term success the impacts of improved community participation may still lead to important longer-term benefits (e.g. in social capital). It will never be the case, however, that project impacts can be considered 'permanent', even though this has increasingly been used as a criterion for assessment of carbon payment for ecosystem services projects. There is an increased trend towards iterative 'adaptive' approaches in CFM projects, e.g. following the methods of 'integrated natural resource management' (Campbell and Sayer 2003). By potentially creating more temporal variability in project activities, this will create particular challenges in terms of the long-duration required for reliable assessment of project outcomes.

Drawing conclusions from the current evidence base is hampered by the methodological designs and diverse outcomes of the research conducted to date. A minimum quality of study design, which will contribute useful data to a future updated review, whilst also being realistically feasible, should be provided for guidance to inform evaluation of CFM initiatives. Standard outcome measures that are recognised indicators of the success of management should be proposed so that they are common across projects. Higher standards of reporting of study context and baseline data are essential to enable meaningful analysis of reasons for variation in effectiveness of CFM. The use of BACI designs, which allow investigation of the comparability of sites at baseline, along with a full investigation/accounting of further potentially confounding variables affecting the comparability of sites should be possible within the constraints imposed by the socio-economic context of the study. Research should be better integrated into CFM project activities, so that time-course studies can be reported that document changes from the start of a CFM project and during its development (with parallel studies in non-CFM communities). This will provide far stronger evidence about the actual direct effects of the project interventions.

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8. Potential Conflicts of Interest and Sources of Support

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10. Appendices

10.1 APPENDIX A

10.1.1 Studies included in the synthesis

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Sethi, P. and H. Khan (2001). Structuring financial empowerment for localized development within joint forest management (JFM): Examples from Madhya Pradesh, India. *Sustainable Development*, **9**(2): 87-102.

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Thoms, C. A. (2008). Community control of resources and the challenge of improving local livelihoods: A critical examination of community forestry in Nepal. *Geoforum*, **39**(3): 1452-1465.

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Vickers, B. and Mackenzie, C. (2007). *Sharing the wealth? A case study of a pioneering community-based timber harvesting operation in Central Viet Nam, Bangkok Thailand*, FAO Regional Office for Asia and the Pacific.

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Zulu, L. C. (2008). Community forest management in southern Malawi: Solution or part of the problem? *Society & Natural Resources*, **21**(8): 687-703.

10.2 APPENDIX B - The Search Strategy

10.2.1. General Search

Literature databases
The following computerized databases were searched for relevant studies:

- Science and Social Science Citation Index
- British Library for Development Studies
- Scopus
- Agricola
- CAB Abstracts
- PubMed
- EMBASE
- PsycINFO
- Science Direct
- EconLit
- Index to Theses Online
- Directory of Open Access Journals

Internet search engines
An internet search was performed using the following web engines:

- www.google.com
- www.jux2.com
- www.scholar.google.com
- http://scientific.thomsonwebplus.com/
- www.scirus.com (restricted to “web sources” only)

10.2.2. Specialist website search

GEF agencies were contacted for any potentially relevant material, these agencies are:

- The United Nations Development Programme (UNDP)
- The United Nations Environment Programme (UNEP)
- The World Bank
- The African Development Bank (AFDB)
- The Asian Development Bank (ADB)
- The European Bank for Reconstruction and Development (EBRD)
- The Inter-American Development Bank (IDB)
- The International Fund for Agricultural Development (IFAD)
- The UN Food and Agriculture Organisation (FAO)
- The UN Industrial Development Organisation (UNIDO)

The websites of the following specialist organisation were searched to identify further relevant publications for inclusion into the review:

- http://www.capri.cgiar.org/
- http://www.catie.org.ac.cr/

- http://www.cbnrm.net/
- http://www.cgiar.org/
- http://www.cifor.cgiar.org
- http://www.cof.orst.edu/org/istf/ftpp.htm
- http://www.communityforestryinternational.org/
- http://www.conservation.org
- http://www.dfid.gov.uk
- http://www.etfrn.org
- http://www.forestrycenter.org/
- http://forests.org/
- http://www.forestsandcommunities.org/
- http://www.ifad.org/
- http://www.iied.org
- http://www.indiana.edu/~iascp/
- http://www.iucn.org
- http://www.livelihoods.org
- http://www.www.macp-pk.org
- http://www.odi.org
- http://www.www.panda.org
- http://www.pfc.cfs.nrcan.gc.ca/
- http://www.rainforestportal.org/
- http://www.recoftc.org
- http://www.tropenbos.nl/
- http://www.usaid.gov/
- http://www.waldbau.uni-freiburg.de/forlive/Home.html
- http://www.wcs.org

10.3 APPENDIX C - Study characterisation

Table C.1. Summary of categories and response details used to characterise included studies

Category	Item	Type of response
Context of study	Country	Country in which data was collected
	Region	Region of country specified above
	Study aim	The question the study aimed to investigate (usually extracted from the abstract/final paragraph of introduction)
CFM features	Type of CFM	The type of CFM under study, based on the author's terms
	No. of forests	No. of forests in the study
	No. of villages	No. of villages in the study
	Independence of test	Are the numbers of forests/villages independent tests of the effectiveness of CFM implementation?
	Age of CFM	How many years has CFM been implemented before the data had been collected?
	Size of CFM	What is the area of land under CFM?
CFM implementation	CFM participation	Is any information given on the participation of individuals (e.g. decision/rule making) in CFM?
	CFM enforcement	Is any information given on the enforcement of CFM (patrolling/sanctions)?
Comparator if site comparison:	Type	Before/after or site comparison
	Type	Type of forest in site comparison e.g. state-managed forest
	No. of forests	No. of comparator forests in the study
	No. of villages	No. of comparator villages in the study
	Independence of test	Are the numbers of forests/villages independent tests of the effectiveness of the alternative management?
	Age of management	How many years has the comparator management been implemented before the data had been collected?
	Size of forest	What is the area of land under the comparator management?
Author selection of sample sites (note different scales)	CFM site	Does the author describe the reasons for investigating the specific CFM sites in the study?
	CFM sampling frame	If random sampling of CFM sites then what is the 'population' from which sites were drawn?
	CFM participants/sub-sites	Does the author describe the selection of participants/sub-sites within each CFM site from which data was collected?
	Comparator site	Does the author describe the reasons for investigating the specific comparator sites in

		the study?
	Comparator participants/sub-sites	Does the author describe the selection of participants/sub-sites within each comparator site from which data was collected?
(Control) of Confounders	Initial CFM placement	Does the author describe why CFM was implemented in the particular site(s)?
	Initial Comparator site placement	Does the author describe why the comparator management was implemented in the particular site(s)?
	Base-line data	Is data available at base-line i.e. before the sites were under different managements?
	Confounders test	Do the authors either show data for or statistically investigate differences between sites that may confound the effects of CFM?
	Other confounders	Is there any discussion elsewhere on differences between CFM and the comparator site that might explain any differences in the outcomes measured?
	Attempt to account for confounders in the analysis	Do the authors attempt to account for any potentially confounding differences in the analysis of the outcome?
	Contamination/spill-over	Is there any evidence that the management in one site affected activities in other sites?
	Inter-site distance	Is the distance between CFM and comparator sites given?
Methodology	Basic details	What techniques/instruments were used to collect the samples?
	Replication CFM	How many samples were collected from each site (or in total if the former was not available)
	Replication Comparator site	How many samples were collected from each site (or in total if the former was not available)
	Validity of methodology	Is there any attempt to verify the validity of the techniques used?
	Withdrawals/ attrition	Was there any loss of sites during the study or sites that could not be sampled?
Outcome	Broad outcome	Based on table 1 in the protocol, list the broad outcomes of the study
	Specific outcome	List of specific outcomes that have been measured and presented in the article.
	Potential for meta-analysis	Is data presented in a form that could be used in a meta-analysis?
Reasons for heterogeneity	Community context	Is there any investigation/discussion of the role of this factor in the effect of CFM?
	Forest/site attributes	Is there any investigation/discussion of the role of this factor in the effect of CFM?
	Tech & Market influences	Is there any investigation/discussion of the role of this factor in the effect of CFM?
	Programme attributes	Is there any investigation/discussion of the role of this factor in the effect of CFM?

	Institution & political context	Is there any investigation/discussion of the role of this factor in the effect of CFM?
Authors conclusions	Score	On a scale of 0, 1 or 2 for none, partial/mixed or full support of the effectiveness of CFM based on authors concluding remarks
Comments	General comments	Any general remarks/extra notes that may be relevant

10.4 APPENDIX D – Description of studies included in the review synthesis

Table D.1. Project characteristics and design of studies included in the review synthesis (livelihood studies not included)

Reference	Location	Project details	Methodology
Adhikari, B., Williams, F., and Lovett, J. C. (2007). Local benefits from community forests in the middle hills of Nepal. *Forest Policy and Economics*, **9**(5): 464-478.	Kavre Palanchok & Sindhu Palanchok districts, Nepal	Type of CFM: community forestry. Measured outcome/s: resource collection: fuel wood, leaf litter, fodder, grass and thatching material Comparator/s: before/after	Methodology: mixed methods – structured surveys used to ascertain current and historical collection; cross-checked with group discussion. Study site selection: 2 districts in Nepal, selected on the basis that they were representative 'forest-dependent' districts. Four forest user groups within each district selected on the basis of maturity (at least 5 years under CFM). Participants/sub-site selection: stratified random

			selection of households: households in each village assigned to income class (v low, low, middle, high) and 20% households from each class randomly selected. 330 households surveyed in total.
Aggarwal, A., R. S. Sharma, et al. (2006). "An ecological assessment of greening of Aravali mountain range through joint forest management in Rajasthan, India." International Journal of Environment and Sustainable Development 5(1): 35-45.	Rajasthan, India	Type of CFM: JFM (plantations and natural forests) across 7 forest divisions (29 Forest Protection Committee) Measured outcome/s: forest condition (diversity, richness, density, basal area, cut stems and size distribution) Comparator/s: areas with similar conditions but no silvicultural interventions	Methodology: quantitative – replicate quadrats (33 in total in the JFMs) Study site selection: divisions were representative of different geographic areas Participants/sub-site selection: not described Confounders not investigated
Ali, T., M. Ahmad, et al. (2007)a. "Impact of participatory forest management on financial assets of rural communities in Northwest Pakistan." Ecological Economics 63(2-3): 588-593.	North West Frontier Province, Pakistan	Type of CFM: participatory forest management (PFM). Measured outcome/s: number and type of income sources, savings and access to loans. Comparator/s: villages not participating in PFM.	Methodology: questionnaire survey, interviews with key informants, focus groups Study site selection: 4 villages in 2 districts randomly selected (method not reported) from all PFM project villages in districts

			Participants/sub-site selection: random selection (method not reported) of 50 households per village (both study sites and comparators)
Ali, T., M. Ahmad, et al. (2007)b. "Impact of participatory forest management on vulnerability and livelihood assets of forest-dependent communities in northern Pakistan." International Journal of Sustainable Development and World Ecology 14(2): 211-223.	North West Frontier Province, Pakistan	Type of CFM: participatory forest management (PFM). Measured outcome/s: Distance, access and density of the nearest forests to house, change in forest cover & illegal wood cutting, institutional access to timber,, means of obtaining timber, degree of trust/relationship between respondents & state institutions, perceived performance and participation in Village Development Committees (VDCs) and Women's Organisations (WO), sources of income & seasonality, household illness – the latter 2 outcomes not for comparators. Comparator/s: villages not participating in PFM.	Methodology: questionnaire survey, interviews with key informants, focus groups Study site selection: 4 villages in 2 districts randomly selected (method not reported) from all PFM project villages in districts Participants/sub-site selection: random selection (method not reported) of 50 households per village (both study sites and comparators)
Bandyopadhyay, S. and Shyamsundar, P. (2004). Fuelwood consumption and participation in	Andhra Pradesh, Madhya Pradesh, Orissa, West Bengal, and Uttar Pradesh, India	Type of CFM: community forestry. Measured outcome/s: fuel wood collection.	Methodology: analysis of secondary data from the 54th round of India's National Sample Survey.

community forestry in India. *World Bank Policy Research Working Paper*: 3331.		Comparator/s: villages not participating in community forestry.	Study site selection: data from 5 states, selected on the basis that these had the largest number of forest user groups at the time of survey. Participants/sub-site selection: random stratified – c. 16 households randomly selected from each village. Comparator households matched (propensity score matching).
Blomley, T., K. Pfliegner, et al. (2008). "Seeing the wood for the trees: an assessment of the impact of participatory forest management on forest condition in Tanzania." Oryx 42(3): 380-391. case study 1	Eastern, central and northern Tanzania	Type of CFM: Participatory forest management(9 Community-based and 12 joint-forest management) Measured outcome/s: forest condition (basal area, volume increment and stems per ha) Comparator/s: site comparison (1 open access and 1 local government management)	Methodology: quantitative – Permanent sample plots - 246 across all 13 sites Study site selection: not described Participants/sub-site selection: not described Confounders not investigated
Blomley, T., K. Pfliegner, et al. (2008). "Seeing the wood for the trees: an assessment of the impact	Monogoro Rural and Kibaha Districts, Tanzania	Type of CFM: Joint forest management (3) Measured outcome/s: resource	Methodology: quantitative – Transects(area sampled covers 0.4-0.6% of the total forest)

of participatory forest management on forest condition in Tanzania." Oryx 42(3): 380-391. case study 2		extraction; human use/disturbance and forest condition (number of trees dbh and height) Comparator/s: site comparison (3 traditional state management)	Study site selection: Paired by forest site Participants/sub-site selection: random Confounders not investigated
Blomley, T., K. Pfliegner, et al. (2008). "Seeing the wood for the trees: an assessment of the impact of participatory forest management on forest condition in Tanzania." Oryx 42(3): 380-391. case study 3	Eastern Arc Mountain, Tanzania	Type of CFM: joint-forest management (24) Measured outcome/s: pole and timber harvesting Comparator/s: site comparison (25 local or central government management)	Methodology: quantitative – 477km of transects Study site selection: not described Participants/sub-site selection: not described Confounders not investigated
Bray, D. B., Duran, E., Ramos, V.H., Mas, J.F., Velazquez, A., McNab, R.B., Barry, D., Radachowsky, J. (2008). Tropical Deforestation, Community Forests, and Protected Areas in the Maya Forest. *Ecology and Society*, 13(2).	The Maya Forest region, Mexico and Guatemala	Type of CFM: community forestry. Measured outcome/s: land use/land cover change. Comparator/s: protected areas.	Methodology: quantitative – land-use and land cover maps constructed from satellite images. Study site selection: Maya forest region of Mexico and Guatemala. Selected on the basis of biophysical similarity and maturity of community forestry groups.

			Participants/sub-site selection: N/A – whole area studied.
Calderon, M. M. and A. A. Nawir (2006). "An evaluation of the feasibility and benefits of forest partnerships to develop tree plantations: case studies in the Philippines." CIFOR Working Paper(No.27): xi + 72 pp.	Luzon, Mindanao, Viasayas regions, Phillipines	Type of CFM: community forest management. Measured outcome/s: NPV (net present value), IRR (internal rate of return) Comparator/s: areas under Integrated Forest Management	Methodology: quantitative – questionnaires and documentary (statistics obtained from reports) Study site selection: non-random, selected on basis of accessibility and likelihood of response. Participants/sub-site selection: not clear, participants were "stakeholder groups"
Dalle, S. P., de Blois, S., Caballero, J., and Johns, T. (2006). Integrating analyses of local land-use regulations, cultural perceptions and land-use/land cover data for assessing the success of community-based conservation. *Forest Ecology and*	Quintana Roo, Mexico	Type of CFM: community forestry. Measured outcome/s: land use/land cover change. Comparator/s: before/after.	Methodology: quantitative – land-use and land cover maps constructed from satellite images. Study site selection: Single ejido, X-Maben, in the Quintana Roo state of Mexico. Rationale for selection not described.

Management, **222**(1/3): 370-383.			Participants/sub-site selection: N/A – whole area studied.
Edmonds, E. V. (2002). Government-initiated community resource management and local resource extraction from Nepal's forests. *Journal of Development Economics*, **68**(1): 89-115.	Arun Valley, Nepal	Type of CFM: community forestry. Measured outcome/s: fuel wood collection. Comparator/s: households in communities without Forest User Groups.	Methodology: analysis of secondary data from 1995/1996 Arun Valley Living Standards (AVLS) survey and an administrative census of forest groups. Study site selection: Arun Valley, eastern Nepal. Rationale for selection not described. Participants/sub-site selection: N/A – all households surveyed as part of AVLS. Comparator households matched to control for observables.
Eeden, D. G. v., B. J. v. Rensburg, et al. (2006). "The value of community-based conservation in a heterogeneous landscape: an avian case study from sand forest in Maputaland, South	KwaZulu Natal province, South Africa	Type of CFM: Community-based natural resource management (recently nominated "Tshanini Community Conservation Area") Measured outcome/s: sand forest bird assemblages	Methodology: quantitative – Visual and auditory bird surveys Study site selection: rare habitat Participants/sub-site selection: not described

Africa." South African Journal of Wildlife Research 36(2): 153-157.		Comparator/s: site comparison (Tembe Elephant Park)	Confounders not investigated
Ellis, E. A. and Porter-Bolland, L. (2008). Is community-based forest management more effective than protected areas? A comparison of land use/land cover change in two neighboring study areas of the Central Yucatan Peninsula, Mexico. *Forest Ecology and Management*, **256**(11): 1971-1983.	Central Yucatan Peninsular, Mexico	Type of CFM: community-based forest management. Measured outcome/s: land use/land cover change. Comparator/s: protected areas.	Methodology: quantitative – land-use and land cover maps constructed from satellite images. Study site selection: Two adjacent areas within the Central Yucatan Peninsular Region, La Montana, Campeche, and Zona Maya, Quintana Roo. Areas similar in biophysical, landscape and community characteristics. Participants/sub-site selection: N/A – whole area studied.
Gautam, A. P., Webb, E. L., and Eiumnoh, A. (2002). GIS assessment of land use/land cover changes associated with community forestry implementation in the Middle Hills of Nepal. *Mountain Research and*	Kabhepalanchok district, Nepal	Type of CFM: community forestry. Measured outcome/s: land use/land cover change. Comparator/s: before/after; villages without formalised community forestry.	Methodology: quantitative – digitized land-use and land cover maps constructed from existing maps and ground-verified aerial photographs. Study site selection: Roshi watershed, Middle Hills, Nepal. Selected on the basis

Development, **22**(1): 63-69.			of representativeness and length of implementation of community forestry. Participants/sub-site selection: N/A – whole watershed studied.
Gautam, A. P., Shivakoti, G. P., and Webb, E. L. (2004). Forest cover change, physiography, local economy, and institutions in a mountain watershed in Nepal. *Environmental Management*, **33**(1): 48-61.	Kabhepalanchok district, Nepal	Type of CFM: community forestry. Measured outcome/s: land use/land cover change. Comparator/s: before/after; government management.	Methodology: quantitative – land-use and land cover maps constructed from satellite images. Study site selection: Upper Roshi watershed, Middle Hills, Nepal.selected on the basis of representativeness and length of implementation of community forestry. Participants/sub-site selection: N/A – whole area studied.
Gautam, A. P. and G. P. Shivakoti (2005). "Conditions for successful local collective action in forestry: some evidence from the Hills of Nepal." Society & Natural	Kabhrepalanchok district, Nepal	Type of CFM: community forestry (1) Measured outcome/s: forest condition (perceived forest condition by users and forester, basal area, tree density, richness)	Methodology: quantitative – 30/40 forest plots (also used qualitative research methods) Study site selection: the two sites were selected on the basis of governance and

Resources 18(2): 153-171.		Comparator/s: site comparison (1 semigovermemt)	different changes in tree cover Participants/sub-site selection: random Data shown on various geographic factors and discussion of historical degradation.
Gupta, R., S. K. Srivastava, et al. (2004). "Impact of participatory forest management on socio-economic development of rural people: A case study in Kodsi and Talaichittor villages of Dehra Dun District." Indian Forester 130(3): 243-252.	Dehra Dun District, Uttaranchal State, India	Type of CFM: PFM Measured outcome/s: sources of income, change in family income, savings, sources of fuel, fuelwood/fodder collection, distance covered/time spent in fuelwood/fodder collection), wheat & paddy production Comparator/s: before/after	Methodology: Questionnaire survey, participatory rural appraisal, semi-structured interviews Study site selection: random selection of 2 villages, method not reported, from all PFM villages in area Participants/sub-site selection: purposive selection of households - quotas for ethnic group and income strata.
Grundy, I., J. Turpie, et al. (2000). "Implications of co-management for benefits from natural	Mzola State Forest, North West Zimbabwe	Type of CFM: joint forest management (JFM). Measured outcome/s: net present	Methodology: model - data for model gathered from studies (publ. and unpubl.) from Mzola or similar area in

resources for rural households in north-western Zimbabwe." Ecological Economics (Amsterdam) 33(3): 369-381.		value Comparator/s: modelled 'no JFM' scenario	Zimbabwe plus from local officials and key informants - not clear if questionnaire used or not Study site selection: not clear Participants/sub-site selection: N/A – whole area studied.
Kassa, H., B. Campbell, et al. (2009). "Building future scenarios and uncovering persisting challenges of participatory forest management in Chilimo Forest, Central Ethiopia." Journal of Environmental Management 90(2): 1004-1013.	Chilimo National Forest Priority Area, Ethiopia	Type of CFM: PFM. Measured outcome/s: estimated average annual household income, sources of income Comparator/s: modelled 'no PFM' scenario	Methodology: model - data for model gathered from key informant interviews plus some other non-specified sources of data Study site selection: not clear Participants/sub-site selection: purposive selection of stakeholders for key informant interviews, to represent weatlh/age/FUG membership.
Kohlin, G. and G. S. Amacher (2005). "Welfare implications of	Dhani Reserve Forest, Orissa, India	Type of CFM: community forest plantations	Methodology: quantitative – questionnaire survey

community forest plantations in developing countries: the Orissa Social Forestry Project." American journal of agricultural economics 87(4): 855-869.		Measured outcome/s: time spent in collection, estimated value of this collection Comparator/s: no community forest	Study site selection: random selection of villages (method not reported) Participants/sub-site selection: random selection of households (method reported).
Kumar, S. (2002). "Does "Participation" in Common Pool Resource Management Help the Poor? A Social Cost-Benefit Analysis of Joint Forest Management in Jharkhand, India." World Development 30(5): 763-782.	Northern Ranchi District, Jharkhand State, India	Type of CFM: JFM Measured outcome/s: stems per ha extraction, Net Present Value Comparator/s: government managed forest	Methodology: quantitative – questionnaire survey, prices obtained from local markets Study site selection: non random selection of villages (method not reported) Participants/sub-site selection: random selection of households (method not reported).
Maharjan MR., Ram Dakal T., Thapa Suresh K., Schreckenberg K., Luttrell C., (2009). Improving benefits to the poor from community forestry in the Churia	Central and Mid-Western Nepal	Type of CFM: community forestry Measured outcome/s: annual per capita income, % income from forest-related activities, % income from community forestry, per capita costs of community forestry, composition	Methodology: Particpatory Rural Appraisal (PRA) with groups and in village meetings, key informant interviews, structured questionnaire

region of Nepal. International Forestry Review, 11(2):254-267.		of CFUG committees, perception of governance – some outcomes presented for different "well-being" groups Comparator/s: no CF, before/after	Study site selection: non random selection of communities (method not reported) Participants/sub-site selection: random selection of households (method not reported)
Mishra, T. K. and S. K. Banerjee (1997). "An ecological reconnaissance of lateritic forest of South West Bengal." Advances in Forestry Research in India 16: 1-43.	South-West Bengal, India	Type of CFM: Joint forest management (6 coppice Sal forests) Measured outcome/s: number and diversity of tree/shrub/herb species Comparator/s: site comparison (Preservation plots)	Methodology: 12 quadrats of different sizes at each site Study site selection: random from 2 forest divisions Participants/sub-site selection: random Confounders not investigated
Nagendra, H. (2002). "Tenure and forest conditions: community forestry in the Nepal Terai." Environmental Conservation 29(4): 530-539.	Terai lowlands (Chitwan district), Nepal	Type of CFM: recently notified community forest (2) Measured outcome/s: local residents perception of change, forester's opinion, tree/sapling density, diversity, richness, diameter and height	Methodology: 20 - 40 forest plots per forest and evaluation by a forester (also interviews with users) Study site selection: selected to cover a range of altitudes and paired by common user groups

		Comparator/s: site comparison (3 national forest and national park)	Participants/sub-site selection: random Confounders not investigated
Nagendra, H., Pareeth, S., Sharma, B., Schweik C. M., and Adhikari K. R. (2008). Forest fragmentation and regrowth in an institutional mosaic of community, government and private ownership in Nepal. *Landscape Ecology*, **23**(1): 41-54.	Chitwan Valley, Nepal	Type of CFM: community forestry; and "buffer zone management" (also described as co-management. Measured outcome/s: land use/land cover change. Comparator/s: "park periphery"; "surrounding landscape".	Methodology: land-use and land cover maps derived from satellite images. Study site selection: area in the Chitwan Valley selected on the basis that the landscape contains a representative "institutional mosaic". Participants/sub-site selection: N/A – whole area studied.
Niesenbaum, R. A., M. E. Salazar, et al. (2005). "Community forestry in the Mayan Biosphere Reserve in Guatemala." Journal of Sustainable Forestry 19(4): 11-28.	Mayan Biosphere Reserve, Guatemala	Type of CFM: community forestry Measured outcome/s: annual income generation from CF, participation in CF, mean annual incremental growth rates, size-class distribution of trees, mean abundance of saplings Comparator/s: Livelihood outcome - before and after. Forest management	Methodology: 20 permanent harvest plots, questionnaire survey Study site selection: not clear - part of biosphere reserve and MAB programme Participants/sub-site selection: not reported for

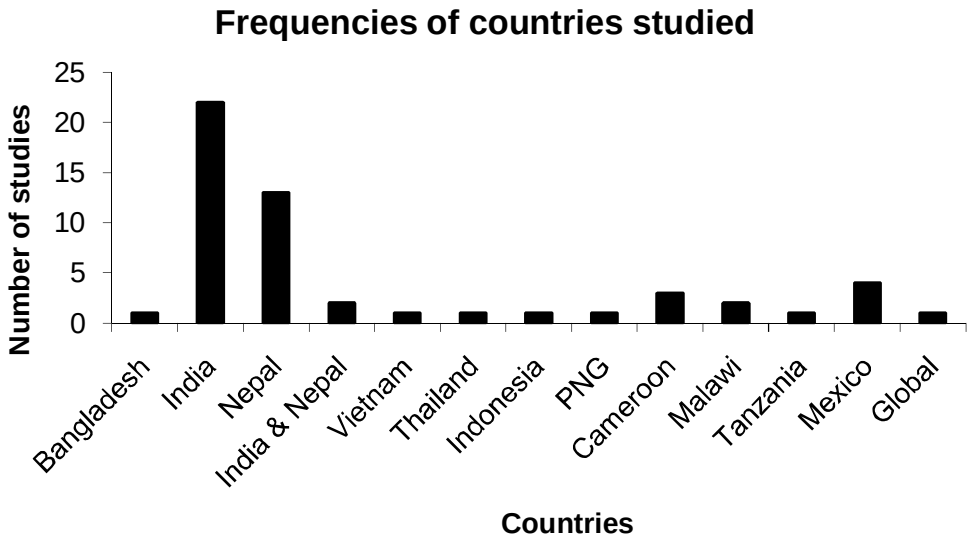
		outcomes - compares harvested plots with control plots within same forest	harvest plots, random (method not reported) for survey
Somanathan, E., Prabhakar, R., and Mehta, B. S. (2009) Decentralization for cost-effective conservation. *PNAS*, **106**: 4143 - 4147.	Central Himalayas, India	Type of CFM: council forest management. Measured outcome/s: forest cover; crown cover. Comparator/s: areas under state management.	Methodology: digitized land cover map derived from satellite image. Study site selection: 10 adjoining areas in central and eastern Uttarakhand. Participants/sub-site selection: N/A – all 271 villages (and adjoining forests) in study area. Addressed issue of potential confounding using three approaches: an examination of the influence of spatial proximity, multiple regression with a number of explanatory variables, and propensity score matching.
Sreedharan, C. K. and Dhanapal, K. (2005). Monitoring of Tamil Nadu Afforestation Project (TAP) using IRS 1D satellite imagery - a	Tiruvannmalai district, Tamil Nadu, India	Type of CFM: joint forest management. Measured outcome/s: land use/land cover change.	Methodology: land cover maps derived from satellite images. Study site selection: A single village, Jothinagar Village in

case study in Jothinagar Village, Tiruvannamalai District, Tamil Nadu. *Indian Forester*, **131**(6): 735-740.	Comparator/s: before/after.	the Tiruvannamalai District, Tamil Nadu selected for study. Participants/sub-site selection: N/A – whole village area studied.

10.5 APPENDIX E – Characterisation of studies without appropriate comparators

The following figures present the frequency of studies without relevant comparators for different countries and different outcomes.

The distribution of studies is broadly similar to that of studies included in this review, with most studies in India and Nepal.



The number of studies in different outcome categories shows that more livelihood studies have been conducted without the use of a comparator. Some outcomes, such as carbon sequestration and food security were found in studies without comparators but not in any study with a comparator; for this reason, no studies with these outcomes were included in the review.