Environmental Science & Policy 55 (2016) 167–177

Contents lists available at ScienceDirect

Environmental Science & Policy

journal homepage: www.elsevier.com/locate/envsci

The impacts of shifting cultivation on secondary forests dynamics in tropics: A synthesis of the key findings and spatio temporal distribution of research

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ARTICLE INFO

Article history:
Received 6 November 2014
Received in revised form 2 October 2015
Accepted 5 October 2015

Keywords:
Deforestation
Secondary forest
Agriculture
Environmental consequence
Conservation

ABSTRACT

Shifting cultivation has been attributed to causing large-scale deforestation and forest degradation in tropical forest-agriculture frontiers. This view has been embedded in many policy documents in the tropics, although, there are conflicting views within the literature as to the impacts of shifting cultivation. In part, this may be due to the complex nature of this land use making generalizations challenging. Here we provided a systematic map of research conducted on shifting cultivation in tropics. We first developed a literature search protocol using ISI Web of Science that identified 401 documents which met the search criteria. The spatial and temporal distribution of research related to shifting cultivation was mapped according to research focus. We then conducted a meta-analysis of studies ($n = 73$) that focused on forest dynamics following shifting cultivation. A bias in research on anthropology/human ecology was evident, with most research reported from the tropical Asia Pacific region (215 studies). Other key research foci were – soil nutrients and chemistry (72 studies), plant ecology (62 studies), agricultural production/management (57 studies), agroforestry (35 studies), geography/land-use transitions (26 studies). Our meta-analysis revealed a great variability in findings on selected forest and environmental parameters from the studies examined. Studies on ecology were mainly concentrated on plant diversity and successional development, while conservation biology related studies were focused on birds. Limited impacts of shifting cultivation on some soil essential nutrients were also apparent. Apart from the intensity of past usage site spatial attributes seems critical for the successful development of fallow landscapes to secondary forests. Further research is needed to help ascertain the environmental consequences of this traditional land-use on tropical forests. Scientists and policy makers also need to be cautious when making generalizations about the impacts of shifting cultivation and to the both the social and environmental context in which shifting cultivation is being undertaken.

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1. Introduction

Shifting cultivation, swidden or slash-and-burn is a widespread land-use common in the tropical forest agriculture frontier, and has formed the basis of land uses, livelihoods and customs in upland areas for centuries (Dressler et al., 2015; van Vliet et al., 2012; Mertz et al., 2009a; Metzger, 2003). While reliable information on the number of people who engaged in shifting cultivation is unavailable, Mertz et al. (2009b) has estimated about 14–34 million people alone from tropical Asia depend on shifting cultivation. In tropical regions, it has also been estimated that shifting cultivation is responsible for as much as 60 percent of the total deforestation and is considered as a prominent source of greenhouse gas emissions (Davidson et al., 2008; Geist and Lambin, 2002). At the same time, however, this traditional land-use practice remains central to the livelihoods, culture and food security of millions of people in tropical region (Dalle et al., 2011). In tropical developing countries, the practice of shifting cultivation is sometimes synonymous with poverty and low productivity of

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http://dx.doi.org/10.1016/j.envsci.2015.10.005
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land (Schroth et al., 2004). In recent years, the extent of land under shifting cultivation and the people who depend on it for livelihoods and food security has been declining due to rapid urbanization and economic development in some countries (van Vliet et al., 2012; Mertz et al., 2009a). In many parts of South and South East Asia, local and regional land-use and development policies have been developed to reduce shifting cultivation due to a perceived negative impact on environment (van Vliet et al., 2012; Fox et al., 2009). There is, however, growing recognition from scientists of the importance of this traditional land-use to small holder's livelihoods and food security (Fox et al., 2009; Mertz et al., 2009a,b; Ziegler et al., 2011). At the same time, controversies still persist among policy makers and the scientific community on the suitability of this traditional land-use from environmental and conservation perspectives (Bruun et al., 2009; Lawrence et al., 2010a).

Shifting cultivation is still a dominant land-use/practice in countries rich in biodiversity and forest cover, and many of these countries also has some of the highest rates of deforestation (Baccini et al., 2012). Understanding shifting cultivation is therefore critical for sustainable forest management, biodiversity conservation, and proper land-use and development planning in tropical regions (DeFries and Rosenzweig, 2010). The issues associated with shifting cultivation however, are complex, and involve the intersection of socio-economic, environmental and policy issues. In recent years evidence-based science has been embraced by scientific communities as a desirable approach to design appropriate environmental policies (Lele and Kurien, 2011). In this paper, we review and analyze empirical research on shifting cultivation following a protocol. Our focus was on the spatio-temporal patterns of research on shifting cultivation across the tropics in order to identify research trends and gaps in research. We then performed a meta-analysis of literature that focused on forest dynamics following shifting cultivation with emphasis on the effect of shifting cultivation on key forest and environmental parameters including - plant ecology, conservation biology, soil nutrients and chemistry, and soil physics and hydrology. We finally presented a meta analysis where selected environmental attributes were compared with primary forests and/or other tree based land-use/cover. The drivers of change of shifting cultivation in tropics, with related livelihoods and environmental consequences have been reviewed by van Vliet et al. (2012) based on an analysis of the literature between 2000 and 2010. We extend that analysis to include papers published from 1950 to 2014. Importantly, our study builds on van Vliet et al. (2012) by providing more detailed analysis of the dynamics of tropical secondary forests after shifting cultivation, and factors that may influence the recovery of such landscapes. Our paper provides a general overview of the research on shifting cultivation, gaps in research and secondary forest dynamics after shifting cultivation. Uncovering such issues with greater certainty is useful for both conservation and management of declining tropical forests.

2. Methodology

2.1. Document search for systematic map

We searched the relevant literature using the ISI Web of Science (WoS, Thomson Reuters) database (Web of Science, 2014). WoS was selected as it is one of the most powerful, comprehensive, and widely used search engine for the analysis of interdisciplinary and peer-reviewed literature (Jasco, 2005). There are many terms that have been used locally to explain shifting cultivation (e.g. *jhum* in Bangladesh and parts of India, *kaingin* in the Philippines, *bhasme* in Nepal, *ladang* in Indonesia, *conuco* in Venezuela, *tavy* in Madagascar etc.). However, shifting cultivation, swidden and slash-and-burn are the most commonly used and generally accepted terms that have been used to delineate this land-use (Mertz et al., 2009a. In our literature search we used a combination of those keywords using the search term – (shifting cultivation or swidden or ('slash and burn') in the title. Our review was limited to peer-reviewed articles published between January 1950 and January 2014.

Our search initially yielded 551 documents of which 460 were relevant to our study (Supplementary material 1). All 460 retrieved documents were then reviewed based on their title and abstract to evaluate their suitability for inclusion in the final review. We considered only the articles that reported empirical studies from tropical countries. We then excluded any review, meta-analysis, methodological paper, and paper from outside the tropics (Fig. 1). This resulted in a list of 401 articles that met our final selection criteria.

Supplementary material related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.envsci.2015.10.005.

2.2. Document characterization

We classified the documents according to their main research subject focus (Table 1) as interpreted through their title, abstract and corresponding journal title and classification. Documents were classified into the following subject categories: (i) agricultural production/management; (ii) agroforestry; (iii) anthropology/human ecology; (iv) conservation biology; (v) geography/land-use transitions; (vi) plant ecology; (vii) soil nutrients and chemistry; (viii) soil physics and hydrology; and (ix) others. The year of the publication and geographic location of the research (i.e. country/region) were noted for each document.

2.3. Document selection for meta-analysis

The main emphasis of our meta-analysis was on the secondary forest dynamics following shifting cultivation and the impacts of shifting cultivation on forest characteristics considering primary or undisturbed forest as control. Therefore, articles from subject foci – plant ecology, conservation biology, soil nutrients and chemistry, and soil physics and hydrology have been included. Since we focused on forest dynamics following shifting cultivation we restricted our analysis only to articles that presented a comparison of the related parameters with undisturbed forests (i.e. primary or secondary forest without prior history of shifting cultivation). Seventy three articles met our final selection criteria for that meta-analysis, comprising 34 studies on plant ecology, 14 studies on conservation biology, 17 studies on soil nutrients and chemistry, and 8 studies on soil physics and hydrology.

2.4. Data interpretation and analysis

For our systematic map we compared the number of research studies on different subjects, conducted in different time span as well as in different geographic regions. We performed Student's *t*-tests with *p*-value (one-tailed) to see any significant difference in number of research studies on shifting cultivation during different time period as well as in different tropical regions. All statistical analyses were implemented using MS Excel and R statistical package (version 3.1.0; R Development Core Team, 2012). For mapping spatial distribution of research on shifting cultivation, we used the package 'rworldmap' (South, 2011; Supplmenetary material 2).

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