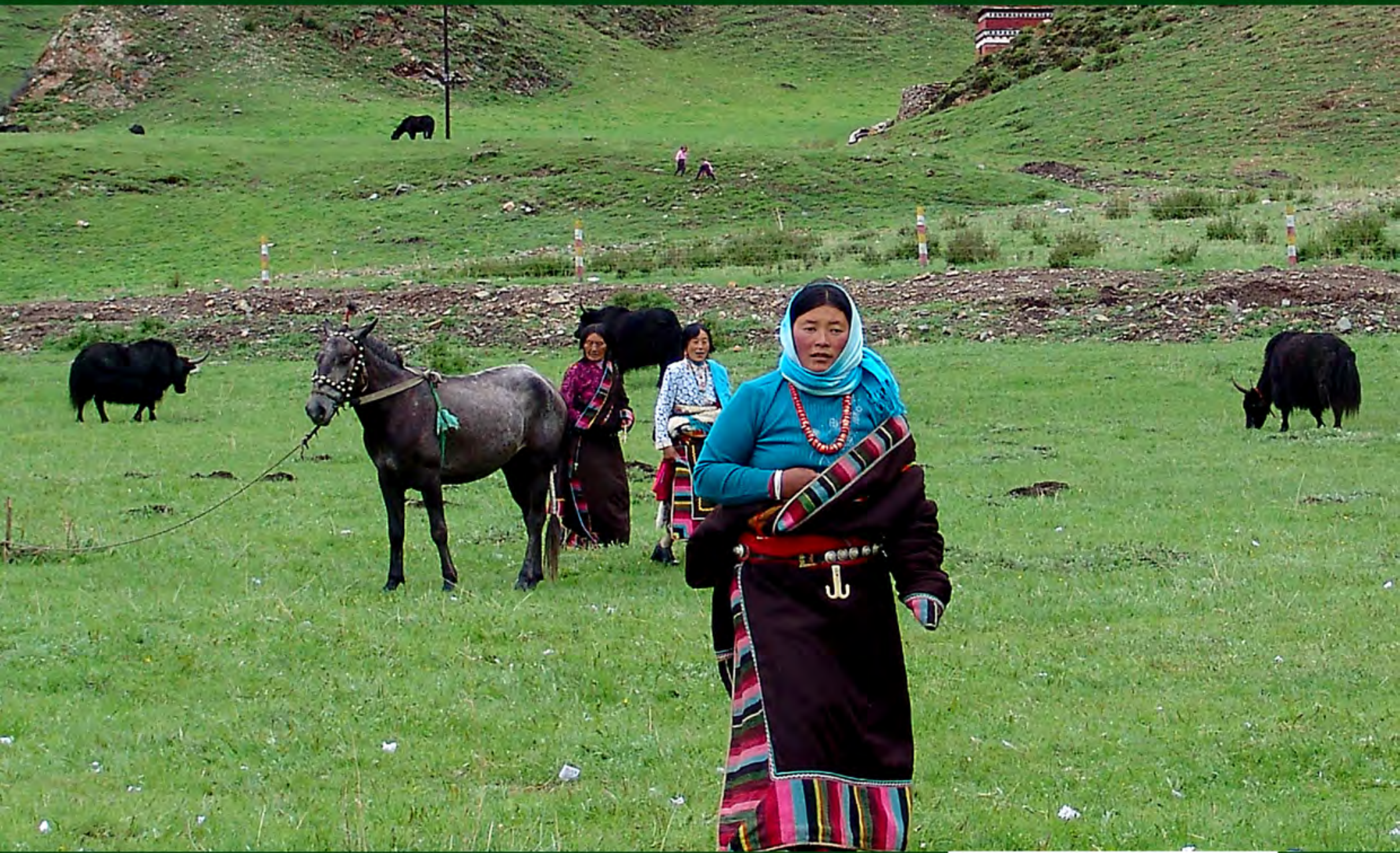
EEPSEA
2015-RR20



Who Walks in the Shadows? Revealing the Blind Spots of the Natural Forest Protection Programme in China

Liu Zhaoyang, Andreas Kontoleon, and Xu Jintao

WorldFish

Published by WorldFish (ICLARM) – Economy and Environment Program for Southeast Asia (EEPSEA)
EEPSEA Philippines Office, WorldFish Philippines Country Office, SEARCA bldg., College, Los Baños, Laguna 4031 Philippines; Tel: +63 49 536 2290 loc. 196; Fax: +63 49 501 7493; Email: admin@eepsea.net

EEPSEA Research Reports are the outputs of research projects supported by the Economy and Environment Program for Southeast Asia. All have been peer reviewed and edited. In some cases, longer versions may be obtained from the author(s). The key findings of most *EEPSEA Research Reports* are condensed into *EEPSEA Policy Briefs*, which are available for download at www.eepsea.org. EEPSEA also publishes the *EEPSEA Practitioners Series*, case books, special papers that focus on research methodology, and issue papers.

ISBN: 978-971-9994-84-8

Front cover photo: Gansu, China by Gill Penney under the creative commons license at https://www.flickr.com/photos/gillpenney/2205729715/

Suggested citation: Liu Z.; A. Kontoleon; and Xu J. Who walks in the shadows? Revealing the blind spots of the Natural Forest Protection Programme in China. EEPSEA Research Report No. 2015-RR20. Economy and Environment Program for Southeast Asia, Laguna, Philippines.

Who Walks in the Shadows?
Revealing the Blind Spots
of the Natural Forest Protection Programme in China

Liu Zhaoyang
Andreas Kontoleon
Xu Jintao

October, 2015

Comments should be sent to:
Mr. Liu Zhaoyang, Downing College, Regent Street, Cambridge, CB2 1DQ, UK
Tel: +44 07721 043150
Email: zl290@cam.ac.uk

The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics. Its goal is to strengthen local capacity in the economic analysis of environmental issues so that researchers can provide sound advice to policymakers.

To do this, EEPSEA builds environmental economics (EE) research capacity, encourages regional collaboration, and promotes EE relevance in its member countries (i.e., Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines, Thailand, and Vietnam). It provides: a) research grants; b) increased access to useful knowledge and information through regionally-known resource persons and up-to-date literature; c) opportunities to attend relevant learning and knowledge events; and d) opportunities for publication.

EEPSEA was founded by the International Development Research Centre (IDRC) with co-funding from the Swedish International Development Cooperation Agency (Sida) and the Canadian International Development Agency (CIDA). In November 2012, EEPSEA moved to WorldFish, a member of the Consultative Group on International Agricultural Research (CGIAR) Consortium.

EEPSEA's structure consists of a Sponsors Group comprising its donors (now consisting of IDRC and Sida) and host organization (WorldFish), an Advisory Committee, and its secretariat.

EEPSEA publications are available online at http://www.eepsea.org.

ACKNOWLEDGMENT

This research was funded by the Economy and Environment Program for Southeast Asia (EEPSEA). We sincerely appreciate the support and comments of Dr. Herminia Francisco and Prof. Nancy Olewiler, among other EEPSEA staff members and researchers.

The fieldwork of this research was co-funded by the Rights and Resources Initiative (RRI), and was conducted in collaboration with Peking University, the State Forestry Administration of China, and the state-owned forestry enterprises in Gansu and Yunnan provinces. The survey teams consisted of 40 enumerators, composed of college students from Peking University and Beijing Forestry University, among other universities in Beijing. We are grateful for their support and hard work.

TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

1.0 INTRODUCTION **1**
- 1.1 Background 1
- 1.2 Research Questions 2
- 1.3 Significance of the Study 3

2.0 THEORETICAL FRAMEWORK AND HYPOTHESES **4**
- 2.1 The Theoretical Model 4
- 2.2 Hypotheses 6

3.0 DATA AND ESTIMATION METHODS **7**
- 3.1 Data 7
- 3.2 Measurement of Variables 8
- 3.3 Estimation Methods 11

4.0 RESULTS **12**
- 4.1 Impacts of NFPP on Forestry Income 12
- 4.2 Impacts of NFPP on Agricultural Income 14
- 4.3 Impacts of NFPP on Off-Farm Income 15
- 4.4 Impacts of NFPP on Total Income 16

5.0 CONCLUSION **17**

LITERATURE CITED **19**

LIST OF TABLES

Table 1.	Definitions and descriptive statistics of dependent and explanatory variables	9
Table 2.	Impacts of NFPP on the forestry income of indigenous residents	13
Table 3.	Impacts of NFPP on the agricultural income of indigenous residents	14
Table 4.	Impacts of NFPP on the off-farm income of indigenous residents	15
Table 5.	Impacts of NFPP on the total income of indigenous residents	17

LIST OF FIGURES

Figure 1.	Geographic locations of the survey sites	7

WHO WALKS IN THE SHADOWS?
REVEALING THE BLIND SPOTS
OF THE NATURAL FOREST PROTECTION PROGRAMME IN CHINA

Liu Zhaoyang, Andreas Kontoleon, Xu Jintao

EXECUTIVE SUMMARY

It is often conjectured that conservation policies for state-owned forests not only influence the state employees managing these forests, but the indigenous residents living in state forest regions as well. This research explored this conjecture by conducting a case study of the Natural Forest Protection Programme (NFPP) in China. A theoretical model was developed to describe the mechanism as to how NFPP impacts indigenous residents through influencing their labor allocation decisions. The theoretical predictions were then examined through empirical analyses based on household-level micro-data collected from Gansu and Yunnan provinces in Western China. The analyses used alternative indicators of the NFPP intensity, and rigorous econometric methods that controlled for potential selection and endogeneity issues in order to generate reasonable causality inferences. Both the theoretical predictions and empirical results found that NFPP negatively affects the total income of indigenous residents. Scrutiny into the variations of income components revealed that indigenous residents seem to be intensifying agricultural production activities, which implies that NFPP may have caused environmental leakage effects by shifting the environmental pressure from forests to cropland. These factors should be considered when designing prospective state forest reforms in the Western regions of China.

1.0 INTRODUCTION

1.1 Background

More than 70% of the world's forests are officially owned by the state (Sunderlin, Hatcher, and Liddle 2008; White and Martin 2002). A classic conflict for forest rights exists between the state or its local representatives and indigenous people living in state-owned forest regions (Angelsen 2001). In order to improve forest conservation, the government usually relies on command-and-control measures that either regulate specific management patterns of forest resources or establish protected areas in state-owned forest regions (Bulte and Engle 2006). These control measures can become another source of conflict between the government and indigenous residents (West, Igoe, and Brockington 2006; Yasmi, Kelley, and Enters 2013). In order to decrease the potential for such conflicts and reduce enforcement costs, the state (or its local representatives) may prefer to enforce state ownership partially by tolerating some resource use by indigenous residents; in this way, conservation policies affect both the state or its local representatives and the indigenous residents. Non-enforcement of the state ownership may give rise to a de facto comanagement arrangement (Engel, Palmer, and Pfaff 2013), which can make the enforcement and efficacy of forest conservation policies become ambiguous. These conservation policies may have successfully controlled the indigenous residents' forest use; however, the limited alternative livelihood sources available to the indigenous residents is likely to cause them to intensify their production activities since they can no longer use forest resources as a livelihood source. This may cause some unexpected environmental leakage effects (Pfaff and Robalino 2012). Moreover, the interactions between the government and indigenous residents can get more complicated when there is ethnic heterogeneity, since many ethnic minorities have strong customary arrangements and perceptions of forest rights (Hares 2009).

This seems to be the situation with the Natural Forest Protection Programme (NFPP) in China, which aims to suspend or substantially reduce the logging of state-owned forests. The government has been compensating the employees of the state-owned forest enterprises (SOFE), but there is no substantial compensation for non-employees living in state forest regions. In this report, these non-employees are hereinafter referred to as the indigenous residents, since they had been living in state forest regions even before the formation of SOFEs, whose employees are usually migrants from all over the country. Although state ownership dominates in these regions, SOFEs had been sharing some forest benefits with indigenous residents before NFPP was established. For instance, SOFEs provided indigenous residents with cheap access to timber as firewood and building materials; they also tolerated some logging done by indigenous residents in state forests. A number of SOFEs even devolved some state forests to the indigenous residents. In addition, SOFEs used informal employment contracts to hire many indigenous residents for timber production. In the study sites in Western China, “ethnic autonomous areas” are widespread, which bestow upon ethnic minorities the constitutional rights to use and develop their ethnic languages, and to maintain their own cultural and social customs (Hasmash 2009; The State Council 2000). Many of these ethnic minorities have some strong traditions involving forest tenure arrangements and forest use. For instance, Tibetans traditionally rely on timber as building materials, although they are generally very protective of forest resources. NFPP may have different impacts across different ethnic groups arising out of its interactions with the constitutional rights of ethnic minorities to maintain their traditions of forest use.

In China, the state owns nearly 40% of the country’s forestland. The management structure of these state-owned forests is a highly planned system. They are managed by 135 local SOFEs, which follow (theoretically) specific guidelines set by the central government. In 1998, before NFPP was implemented, timber output of SOFEs was 17.70 million cubic meter (m^3), which accounts for 46.59% of the total timber output of the country (The State Forestry Administration 1998). In addition, many of the state forests are located in highly sloped mountainous areas in the upstream regions of many large rivers in China (such as Yellow River and Yangtze River), which provide important environmental services as well as forest products.

The 1998 Yangtze River flooding and other severe natural calamities triggered the implementation of a series of large-scale ecological-restoration programs in China in the late 1990s (Spignesi 2004). NFPP, as one of these ecological-restoration programs, was piloted in 1998; it aimed to suspend or substantially reduce logging and to improve afforestation by SOFEs while compensating them. In China, forests are classified by function—into ecological and commercial forests—and they are usually regulated according to their different functions. Ecological forests are managed primarily for the provision of environmental services, whereas commercial forests are managed for forest products. Therefore, when NFPP was implemented, large areas of state forests were reclassified as ecological forests to ensure the legislative consistency of the program with other forestry regulations. Almost all SOFEs have been enrolled in NFPP. Although NFPP primarily targets state-owned forests, the program has included large areas of communal forests within state forest regions by also reclassifying these as ecological forests (Xu et al. 2006).
The government invested CNY 118.60 billion (~USD 15.2 billion) during the first phase of NFPP (2000–2010), and will invest CNY 244.02 billion (USD 38.21 billion) during the second phase of the program (2011–2020). This makes NFPP a large-scale ecological restoration program in terms of total budget—even larger than the ~USD 2 billion annual budget of the well-known Conservation Reserve Programme, which is the largest payments for environmental services program in the US (Ferris and Siikamäki 2009).

NFPP has caused remarkable impacts on state forest regions. In 2012, the annual timber output of SOFEs was merely 4.94 million m^3, a significant reduction of 72.09% from the output in 1998. The number of employees in 2012 (0.41 million) decreased by 54.93% compared with the number in 1998 (0.91 million) (The State Forestry Administration 2012). Although the impacts of NFPP on SOFEs and their employees are straightforward, the impacts on indigenous residents living in state forest regions are not as clearly understood.

1.2 Research Questions

Based on a case study on the impacts of NFPP on state forest regions in Western China, this study explored the leakage effects of state-forest conservation policies on indigenous residents under the foregoing particular settings:

1. The prior de facto rights of indigenous residents to benefit from state-owned forests may have been affected by the establishment of NFPP, which has put most state-owned forests under conservation but have yet to make appropriate alternative arrangements for these indigenous residents.
2. The indigenous residents in the surveyed areas are located in remote mountainous regions with limited access to alternative livelihood sources that are less dependent on natural resources.

3. The surveyed areas accommodate ethnic minority communities with strong customary arrangements of forest rights and long-lasting traditions involving forest use.

Accordingly, the research questions that were answered in this study include the following:

1. Has NFPP influenced the income of indigenous residents?
2. Has NFPP caused environmental leakage effects by controlling the forest use of indigenous residents, which may have intensified their exploitation of other natural resources?
3. Does NFPP have different impacts across different ethnic groups?

1.3 Significance of the Study

This study contributes new knowledge to the existing literature by providing a rigorous empirical study on the leakage effects of a large-scale state forest conservation program (i.e., NFPP) on indigenous residents. The literature on socioeconomic and environmental leakage effects of conservation policies is already abundant (Pfaff and Robalino 2012). Socioeconomic leakage effects on residents in the neighborhood areas are often found to be caused by restrictions on natural resource use or manifested as the emergence of alternative livelihood sources from conservation policies (e.g., ecotourism) (Andam et al. 2010; Sims 2010). Meanwhile, some studies have explored the spatial dimension of environmental leakage effects, and have found that the conservation of natural resources in an area is often accompanied by an increase in resource use elsewhere (Alix-Garcia, Shapiro, and Sims 2012; Wu 2000).

This study hypothesized that since these indigenous residents used to benefit from state-owned forests through informal comanagement arrangements, the socioeconomic effects of NFPP on indigenous residents may have also been caused by the restrictions on the use of state-owned forests, aside from those on communal forests. The environmental leakage effects explored in this study refer to the situation in which the reduction of forest use through NFPP controls may have consequently forced indigenous residents to intensify their exploitation of other natural resources (such as cropland) due to the limited alternative livelihood sources.

Most of the existing studies on the impacts of NFPP relied on narrative case studies and limited quantitative evidence (Cao et al. 2010; Katsigris 2002; Liu et al. 2008; Wang 2010; Weyerhaeuser, Wilkes, and Kahrl 2005; Xu et al. 2003; Zhu 2012). This is probably because almost all state-owned forests have been enrolled in the program, which has made it difficult to find a pure control group for a more rigorous impact evaluations of state-forest regions. A few rare examples, however, have compared indigenous residents living inside and outside state forest regions to provide more convincing causal evidence on the socioeconomic impacts of NFPP (Liu, Lu, and Yin 2010; Liu et al. 2014; Mullan et al. 2010). This study is distinguished from their work by sampling within state forest regions only for more comparable observations and by using an indicator of the strength of NFPP to identify the impacts of the program.

This study also contributes to policy making to improve the sustainable management of state forests in China while serving the best interests of indigenous residents. NFPP was implemented to combat the resource and financial crises of SOFEs; but the program cannot carry on forever. Some institutional changes need to be implemented to address the problem definitively, especially through state forest tenure reforms—which is the next supposed wave of China's land reforms—following the recent collective forest tenure reform (Xu et al. 2006). Before any decisions are made on the prospective reform, it is important to understand clearly what impacts have been delivered to the SOFEs and indigenous residents by the current institutional arrangements. The potential socioeconomic and environmental impacts on indigenous residents are especially important in the western areas of China; these areas include many of the country's least-developed regions, where forestry serves as a major livelihood source. At the same time, these areas form the watersheds for Yangtze River and Yellow River, and therefore contain the habitats for much of China's rich (but threatened) biodiversity. In view of these considerations, the potential impacts of NFPP can impose new pressure on the already fragile ecosystems and, furthermore, threaten local livelihoods—a situation that might lead to social unrest as a worst-case scenario. Any evidence that may be found to support the conjecture about these impacts should be considered during the policy-making process for the prospective state forest tenure reform.

2.0 THEORETICAL FRAMEWORK AND HYPOTHESES

2.1 The Theoretical Model

Based on the work of Huffman (1980) and Groom et al. (2010), a labor allocation model was tailored in this study to reflect the production decisions of local communities in the NFPP regions. NFPP was modeled as constraints on forest use and off-farm employment opportunities of the local communities. The authors used this model to describe that, in response to the constraints imposed by the NFPP, local households adapt their labor allocation among different production activities, which further influences the composition of their income components and total income. This gives rise to several testable hypotheses proposed in the following section.

Labor allocation decisions of rural households were modeled as the result of household utility maximization subject to constraints on human time. Household members were assumed to receive utility from leisure time (T^L) and goods purchased using household income (Y) at a composite price (P^C). A total amount of human time (T) was allocated among agricultural production (T^A), forestry production (T^F), off-farm work (T^O) and leisure time (T^L). Household income was defined as being generated from agricultural production [$P^A \cdot Q^A (T^A)$], forestry production [$P^F \cdot Q^F (T^F)$], and off-farm work ($W \cdot T^O$), in which P^A and P^F respectively denote the prices of agricultural and forestry products, and W denotes the wage rate of off-farm employment. The authors assumed that the indigenous residents are small-scale consumers/producers faced with the exogenous variables P^C, P^A, P^F, and W. Before NFPP was implemented, labor allocation decisions were modeled as follows:

$$\max_{T^A, T^F, T^O, T^L} U\left\{\frac{1}{P^C} \cdot \left[P^A \cdot Q^A (T^A) + P^F \cdot Q^F (T^F) + W \cdot T^O \right], T^L\right\} \quad \text{Equation (1)}$$

subject to

$$T^A + T^F + T^O + T^L \leq T \ (\lambda_1 > 0). \quad \text{Equation (2)}$$

where λ_1 denotes the Lagrange multiplier associated with Equation (2). This is further defined as

$$U_Y = \frac{\partial U}{\partial Y} > 0, \mathrm{U}_{YY} = \frac{\partial^2 U}{\partial Y^2} < 0, U_L = \frac{\partial U}{\partial T^L} > 0, \ \mathrm{U}_{LL} = \frac{\partial^2 U}{\partial (T^L)^2} < 0,$$

$$Q_A^A = \frac{\partial Q^A}{\partial T^A} > 0, Q_{AA}^A = \frac{\partial^2 Q^A}{\partial (T^A)^2} < 0, Q_F^F = \frac{\partial Q^F}{\partial T^F} > 0, Q_{FF}^F = \frac{\partial^2 Q^F}{\partial (T^F)^2} < 0.$$

The first-order conditions of this maximization problem were

$$\frac{1}{P^C} \cdot U_Y \cdot P^A \cdot Q_A^A - \lambda_1 = 0 \quad \text{Equation (3)}$$

$$\frac{1}{P^C} \cdot U_Y \cdot P^F \cdot Q_F^F - \lambda_1 = 0 \quad \text{Equation (4)}$$

$$\frac{1}{P^C} \cdot U_Y \cdot W - \lambda_1 = 0 \quad \text{Equation (5)}$$

$$U_L - \lambda_1 = 0 \quad \text{Equation (6)}$$

$$T^A + T^F + T^O + T^L - \mathrm{T} = 0 \quad \text{Equation (7)}$$

Labor allocated to agricultural production (T^{A*}) and forestry production (T^{F*}) were solved from

$$Q_A^A = \frac{W}{P^A} \quad \text{and} \quad \text{Equation (8)}$$

$$Q_F^F = \frac{W}{P^F}. \quad \text{Equation (9)}$$

Leisure time (T^{L*}) and off-farm labor supply (T^{O*}) were then solved from Equation (7) and

$$\frac{U_L}{U_Y} = \frac{W}{P^C}. \quad \text{Equation (10)}$$

When NFPP was implemented, logging became strictly controlled; this was modeled as an alternative forestry production function $Q^{NF}(T^F)$ with $0 < Q_F^{NF} = \partial Q^{NF}/\partial T^F < Q_F^F$ and $Q_{FF}^{NF} < 0$. The first-order conditions thereby remained the same. Labor allocated to agricultural production ($\hat{T}^A$) and forestry production ($\hat{T}^F$) were solved from

$$Q_A^A = \frac{W}{P^A} \quad \text{and} \qquad \text{Equation (11)}$$

$$Q_F^{NF} = \frac{W}{P^F}. \qquad \text{Equation (12)}$$

Thus, $\hat{T}^A = T^{A*}$ and $\hat{T}^F < T^{F*}$. According to Equation (10), T^L and Y have to vary in the same direction or both remain unchanged. It can be shown that $\hat{T}^L \geq T^{L*}$ and $\hat{Y} \geq Y^*$ cannot hold simultaneously. Accordingly, $\hat{Y}$ and Y^* can be expressed as

$$\begin{aligned} \hat{Y} &= P^A \cdot Q^A(\hat{T}^A) + P^F \cdot Q^{NF}(\hat{T}^F) + W \cdot (\hat{T}^O - T^{O*} + T^{O*}) \\ &= P^A \cdot Q^A(\hat{T}^A) + P^F \cdot Q^{NF}(\hat{T}^F) + W \cdot (\hat{T}^O - T^{O*}) + W \cdot (T^{O*}) \end{aligned} \qquad \text{Equation (13)}$$

and

$$\begin{aligned} Y^* &= P^A \cdot Q^A(T^{A*}) + P^F \cdot Q^F(T^{F*}) + W \cdot (T^{O*}) \\ &= P^A \cdot Q^A(T^{A*}) + P^F \cdot \int_0^{\hat{T}^F} Q_F^F + P^F \cdot \int_{\hat{T}^F}^{T^{F*}} Q_F^F + W \cdot (T^{O*}). \end{aligned} \qquad \text{Equation (14)}$$

If $\hat{T}^L \geq T^{L*}$, then

$$\hat{T}^O - T^{O*} \leq T^{F*} - \hat{T}^F, \qquad \text{Equation (15)}$$

$$W \cdot (\hat{T}^O - T^{O*}) \leq W \cdot (T^{F*} - \hat{T}^F) < P^F \cdot \int_{\hat{T}^F}^{T^{F*}} Q_F^F, \qquad \text{Equation (16)}$$

$$P^F \cdot Q^{NF}(\hat{T}^F) < P^F \cdot \int_0^{\hat{T}^F} Q_F^F, \qquad \text{Equation (17)}$$

and

$$P^A \cdot Q^A(\hat{T}^A) = P^A \cdot Q^A(T^{A*}), \qquad \text{Equation (18)}$$

which implies that $\hat{Y} < Y^*$. Thus, it is inferred that $\hat{T}^L < T^{L*}$, $\hat{Y} < Y^*$ and $\hat{T}^O > T^{O*}$, implying that the logging restrictions imposed by NFPP would reduce forestry labor supply, forestry income, and total income. However, this would increase off-farm labor supply and off-farm income, although the increase in off-farm income cannot cover the loss of forestry income.

Meanwhile, NFPP would also likely constrain off-farm employment opportunities. SOFEs used to be an important source of off-farm jobs for indigenous residents before NFPP. After the program was implemented, the number of SOFE employees decreased by 54.93%, indicating a significant decrease in labor demand. This was modeled as a constraint on off-farm labor supply of indigenous residents:

$$T^O \leq \bar{T}^O < T^{O*} (\lambda_2 > 0) \qquad \text{Equation (19)}$$

where λ_2 denotes the Lagrange multiplier associated with Equation (19). The first-order conditions of the maximization problem became

$$\frac{1}{P^C} \cdot U_Y \cdot P^A \cdot Q_A^A - \lambda_1 = 0 \qquad \text{Equation (20)}$$

$$\frac{1}{P^C} \cdot U_Y \cdot P^F \cdot Q_F^{NF} - \lambda_1 = 0 \qquad \text{Equation (21)}$$

$$\frac{1}{P^C} \cdot U_Y \cdot W - \lambda_1 - \lambda_2 = 0 \qquad \text{Equation (22)}$$

$$U_L - \lambda_1 = 0 \qquad \text{Equation (23)}$$

$$T^A + T^F + T^O + T^L - T = 0 \qquad \text{Equation (24)}$$

$$T^O - \bar{T}^O = 0 \qquad \text{Equation (25)}$$

Off-farm labor supply is determined by Equation (25): $\tilde{T}^O = \bar{T}^O$. Substituting Equation (22) into Equation (20) and (21),

$$Q_A^A + \frac{\lambda_2}{U_Y} \cdot \frac{P^C}{P^A} = \frac{W}{P^A} \quad \text{and} \qquad \text{Equation (26)}$$

$$Q_F^{NF} + \frac{\lambda_2}{U_Y} \cdot \frac{P^C}{P^F} = \frac{W}{P^F} \qquad \text{Equation (27)}$$

Thus, $\tilde{T}^A > \hat{T}^A = T^{A*}$ and $\tilde{T}^F > \hat{T}^F$. That is to say, when both the logging control and off-farm employment constraints are imposed, relative agricultural income would increase, and the impacts on forestry income would become ambiguous without specifying the production and utility functions.

Leisure time ($\tilde{T}^L$) and off-farm labor supply $\tilde{T}^O$ can be solved by substituting Equation (23) into Equation (22):

$$\frac{U_L + \lambda_2}{U_Y} = \frac{W}{P^C}. \qquad \text{Equation (28)}$$

It can then be proved that $\tilde{Y} < Y^*$. Otherwise, $\tilde{Y} \geq Y^*$and $\tilde{T}^L > T^{L*}$ cannot hold simultaneously, since $\tilde{Y} = P^A \cdot Q^A(\tilde{T}^A) + P^F \cdot Q^F(\tilde{T}^F) + W \cdot \bar{T}^O$, and the marginal returns of agricultural activities [$P^A \cdot Q_A^A(\tilde{T}^A)$] and forestry production [$P^F \cdot Q_F^{NF}(\tilde{T}^F)$] would both be lower than W. In addition, $\tilde{Y} \geq Y^*$ ($\tilde{U}_Y \leq U_Y^*$) and $\tilde{T}^L \leq T^{L*}$ ($\tilde{U}_L \geq U_L^*$) cannot hold simultaneously, since $U_L^* / U_Y^* = \tilde{U}_L + \lambda_2 / \tilde{U}_Y = W/P^C$. In other words, total income would decrease when both the logging control and off-farm employment constraints are imposed.

2.2 Hypotheses

Based on the theoretical model presented in the previous section, the constraints imposed by NFPP on the indigenous communities' forest use and off-farm employment opportunities influence their labor allocation decisions; this would eventually affect their income components and total income. Accordingly, the following hypotheses were derived from the theoretical model:

Hypothesis 1: The impacts of NFPP on the forestry income of indigenous residents can be negative, neutral, or positive. Although the logging control would probably have negative impacts on forestry income, the off-farm employment constraint may lead to more labor allocated to forestry production, and therefore would have positive impacts on forestry income. The direction of the aggregated impacts of NFPP would be ambiguous.

Hypothesis 2: NFPP has increased the agricultural income of indigenous residents.

Hypothesis 3: NFPP has caused negative impacts on the total income of indigenous residents due to the logging control and off-farm employment constraints imposed by the program.

Hypothesis 4: NFPP has different impacts across different ethnic groups.

The fourth hypothesis was formed because ethnic minorities in China have constitutional rights to maintain their own cultural and social customs. Many of the ethnic minorities in the sampling sites have strong traditions involving forest tenure arrangements and forest use. The Chinese government also provides other preferential treatments for ethnic minorities involving economic development (such as aid) and other aspects (such as their exemption from the birth control or the one-child policy) (Bulte, Heerink, and Zhang 2011; Hasmash 2009; The State Council 2000). Enforcing NFPP regulations on these ethnic minority households can compromise their constitutional rights to maintain their traditions involving forest use. Even if NFPP is fully enforced on these ethnic minority households, they are likely to have different adaptation strategies due to certain particular characteristics of their livelihood portfolio. For instance, the language difference may limit their off-farm job opportunities outside their own communities.

3.0 DATA AND ESTIMATION METHODS

The empirical analysis of this study relied on a unique data set collected in Gansu and Yunnan provinces, which contained detailed information on 300 households from 30 villages in the state forest regions of 10 SOFEs. The household, village, and SOFE data were independently collected through the surveys conducted among the indigenous residents, village leaders, and SOFE managers. In order to provide robust empirical evidence, the authors used different estimation methods with different indicators of the intensity of the program.

The first set of regression models (Model Set 1) was estimated first in order to examine the impacts of the program on the total income and income components of indigenous residents. This was done by using an intensity indicator, which is measured by the reduction rate of the SOFE timber output before (1997) and after (2012) NFPP was implemented since the program primarily aimed to control the timber harvest of SOFEs. To examine the impact of the program, the research team collected samples in the state forest regions only, and compared only those indigenous communities where NFPP is being implemented at different levels of intensity. This strategy is more pragmatic than constructing treatment and control groups by sampling communities located inside and outside state forest regions; this might introduce compound treatments and make it difficult to separate the impact of NFPP from the different types of prevailing forest ownership (state/collective) or other potential influencing factors. The econometric analysis was conducted at the household level.

In order to provide robust empirical evidence, the researchers developed a second set of regression models (Model Set 2) using an alternative indicator of the intensity of the program as well as additional econometric techniques to further control for the potential bias. The data and estimation methods are further described in the succeeding parts of this section.

3.1 Data

The data were collected through interview surveys at the household, village, and SOFE levels. The research team conducted the survey in state forest regions in Gansu and Yunnan provinces in the summer of 2013. Figure 1 presents the geographic locations of the survey sites. Stratified random sampling method was used as the sampling strategy. The research team first randomly selected 10 SOFEs, which represent 50% of all the SOFEs in the two provinces. Thereafter, three villages in the forest area of each SOFE were randomly selected. In each village, 10 households were randomly selected, which added up to 300 observations altogether. The base year of most of the data is 2012, but the researchers also asked the respondents to recall certain information (e.g., demographic characteristics, off-farm employment, household durables, and assets) before NFPP was implemented in 1997. These were used as instruments when controlling for potential endogeneity and selection issues in the econometric analysis.

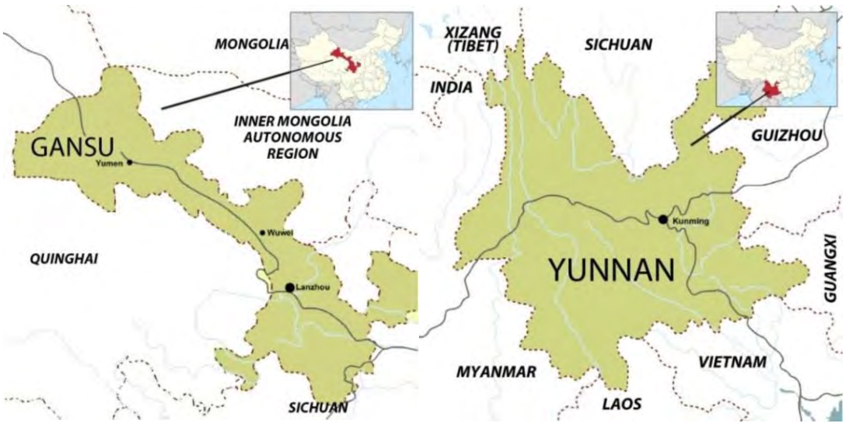


Figure 1. Geographic locations of the survey sites

Note: The figure presents the counties where the surveys took place, instead of the geographic locations of the surveyed villages and SOFEs, out of consideration of the respondents' security.

3.2 Measurement of Variables

Table 1 defines the dependent and explanatory variables, and presents the descriptive statistics used in this study. The NFPP intensity indicator was first measured at the SOFE level by using the reduction rate in the SOFE timber production output compared to the annual output before the program (1997). As a robustness check, an alternative indicator of the NFPP intensity was measured at the household level by the share of ecological forest within the total area of forests managed by an indigenous household.

The income variables were measured following the methods of Haughton and Khandker (2009) and the Poverty Environment Network (2007). The three income components (i.e., forestry income, agricultural income, and off-farm income) were measured through the per capita gross value of products being sold, given away or directly consumed by the household. The total income includes the three income components and transfer payments from the government and relatives.

The other explanatory variables of the total income and income components were selected following the studies of Singh (1999), Nielsen et al. (2013), and Mullan et al. (2010). These explanatory variables are proxies of (1) human capital (e.g., education and other demographic characteristics); (2) natural capital (e.g., land/forestland characteristics); (3) financial capital (e.g., savings); (4) fixed-assets for production; and (5) particular traditions of livelihood patterns (ethnicity).

In addition, the econometric analysis of this study also involved other explanatory variables that would control for the potential selection issue, in which a portion of the sampled households (40 out of 300) do not manage any forestland at all, and the potential endogeneity issue of "ecological forest share" being determined by unobservables correlated with the income variables. Although most of the forests in the sampling sites are owned by the state, indigenous villages also own some communal forests.

After the recent collective forest tenure reform, these communal forests, although still officially owned by village collectives, were contracted to individual households through long-term contracts for their production activities. These allocations of forestland were approved when agreed by at least two-thirds of the members of the villagers' assembly or the committee of villagers' representatives (National People's Congress 2002; Xu, White, and Lele 2010). Therefore, this study considered a household that manages any forestland as a function of the household's land tenure arrangements, the determinants of which were selected following the study of Besley (1995) and of Holden and Yohannes (2002). These determinants included (1) economic and political power of a household (proxied by "land area," "value of durables," "ethnicity," etc.); (2) forestry capacity of a household (proxied by "off-farm workdays," "household size," and "forestry work experience"); and (3) performance of village leaders.

For those forests allocated to individual households, ecological forests were designated based on forestland characteristics, especially the slope, which is highly related to the provision of watershed services and for avoiding soil erosion, landslides, and other geologic disasters. Moreover, designation of ecological forests also reshaped the forest rights of individual households, which often involved interactions between households and other stakeholders, especially the government and its representatives. Therefore, the economic and political power of a household can also influence how ecological forests would be designated. Thus, the corresponding proxies were included as explanatory variables of "ecological forest share."

Table 1. Definitions and descriptive statistics of dependent and explanatory variables

Variable	Definition	Mean	SD	Min	Max
NFPP Intensity Indicator					
Reduction rate in the SOFE timber output	Reduction rate in the 2012 timber output compared to the 1997 output	0.82	0.26	0.32	1.00
Household ecological forest share	Ecological forest share in the total area of forests managed by an indigenous household	0.40	0.46	0.00	1.00
Household Income					
Total income	Gross total income per capita in 2012	8,795.69	8,070.47	1,104.00	48,060.00
Forestry income	Gross forestry income per capita in 2012	1,153.88	4,607.31	0.00	46,666.67
Agricultural income	Gross agricultural income per capita in 2012	1,079.78	2,777.62	0.00	26,497.50
Off-farm income	Gross off-farm income per capita in 2012	4,870.58	5,604.84	0.00	35,000.00
Household Demographic Characteristics					
Ethnicity 2012	Ethnicity of household head in 2012 (0 = Ethnic majority; 1 = Ethnic minority)	0.48	0.50	0.00	1.00
Ethnicity 1997	Ethnicity of household head in 1997 (0 = Ethnic majority; 1 = Ethnic minority)	0.49	0.50	0.00	1.00
Household size 2012	Number of household members in 2012	5.10	1.62	1.00	11.00
Household size 1997	Number of household members in 1997	4.97	1.55	1.00	10.00
Education 2012	Years of educational attainment per capita in 2012	4.99	2.41	0.00	12.21
Education 1997	Years of educational attainment per capita in 1997	3.42	1.96	0.00	9.50
Household Forestland Characteristics					
Forestland area 2012	Total area (mu) of forestland managed by an indigenous household in 2012	62.67	138.14	0.00	1,530.00
Forestland distance to house 2012	Mean distance (km) between the forestland plots and the house in 2012	1.88	1.61	0.00	15.50
Forestland soil 2012	Mean soil conditions of forestland plots in 2012 (0 = Bad; 1 = Medium; 2 = Good)	1.09	0.69	0.00	2.00
Forestland irrigation 2012	Mean irrigation conditions of forestland plots in 2012 (0 = No need for irrigation; 1 = Otherwise)	0.71	0.44	0.00	1.00
Forestland slope 2012	Mean slope of forestland plots (0 = < 15°; 1 = 15~25°; 2 => 25°) in 2012	1.55	0.60	0.00	2.00
Household Land Characteristics					
Land area 2012	Total area (mu) of land managed by an indigenous household in 2012	74.42	144.56	0.20	1,543.90
Land area 1997	Total area (mu) of land managed by an indigenous household in 1997	50.09	89.47	0.00	532.00
Land distance to house 2012	Mean distance (km) between the land plots and the house in 2012	1.50	1.30	0.00	12.20
Land soil 2012	Mean soil conditions of land plots (0 = Bad; 1 = Medium; 2 = Good) in 2012	1.11	0.62	0.00	2.00

Table 1 continued

Variable	Definition	Mean	SD	Min	Max
Household Land Characteristics					
Land irrigation 2012	Mean irrigation conditions of land plots (0 = No need for irrigation; 1 = Otherwise) in 2012	0.80	0.35	0.00	1.00
Land slope 2012	Mean slope of land plots (0 = < 15°; 1 = 15~25°; 2 => 25°) in 2012	1.10	0.60	0.00	2.00
Other Household Characteristics					
Fixed assets 2012	Monetary value of fixed assets for production in 2012	18,212.25	125,546.00	0.00	2,135,900.00
Savings 2012	Savings in 2012	9,169.71	38,679.11	0.00	562,500.00
Value of durables 1997	Monetary value of durables in 1997 (inflation-adjusted)	1,615.77	6,236.95	0.00	53,914.33
Off-farm workdays 1997	Total amount of off-farm workdays of all the members of a household in 1997	104.31	192.97	0.00	1,300.00
Village and Province Characteristics					
Performance of village leaders 1997–2012	A score given by respondents to reflect whether village leaders were being fair, whether they were reliable, and whether they served the best interests of the villagers (0 = Very bad; 10 = Very good).	7.35	2.26	1.00	10.00
Yunnan	0 = Gansu province; 1 = Yunnan province	0.60	0.49	0.00	1.00

Notes: (1) All the monetary values were measured in CNY (1 CNY = 0.1584 USD in 2012). (2) 1 mu = 0.07 ha. (3) SD = standard deviation

3.3 Estimation Methods

As mentioned previously, the researchers sampled in state forest regions only and then used an indicator of the NFPP intensity to examine the impacts of the program, instead of constructing treatment and control groups by sampling households living inside and outside state forest regions. The research team did not undertake the latter so as to avoid introducing compound treatments that would make it difficult to separate the NFPP treatment from potentially influencing factors, such as the type of dominating forest ownership (state/collective) and geographic locations (e.g., different counties). Although most SOFEs have been enrolled in NFPP, the program is not being implemented at the same scale and coverage as the SOFEs, since the ecological benefits and opportunity costs of conserving state forests vary across different locations. For instance, these SOFEs are usually faced with different logging quota arrangements or have different shares of forests designated as ecological forests, representing different intensities of forest use control. Therefore, when evaluating the impacts of NFPP, this study treated the program as having full coverage but with non-uniform intervention in state forest regions by using an indicator of the intensity of the program; this is considered an important methodological option when evaluating the impacts of full-coverage programs (Gertler et al. 2011; Rossi, Lipsey, and Freeman 2004). For instance, Sims (2010) used the share of protected land within the total area of a locality to evaluate the impacts of protection areas. Studies have been undertaken in China that used such intensity indicators to evaluate the impacts of the logging quota scheme (Xie et al. 2013) and the SOFE reforms (Jiang et al. 2014). In order to check the robustness of the findings, the authors estimated two sets of regression models using alternative proxies of the NFPP intensity to examine the impacts of the program on the indigenous residents' incomes.

In the first set of models (Model Set 1), the NFPP intensity was proxied by "reduction rate of the SOFE timber production output." A series of OLS/tobit models regarding the indigenous residents' total, agricultural, and off-farm incomes were first developed. Based on data characteristics, the agricultural and off-farm income components were modeled as tobit variables, and the total income was modeled as a continuous variable. The Huber/White/sandwich estimators were used to provide robust variances. The McKelvey and Zavoina's R^2 estimators were used to measure the fitness of the tobit models, which were considered to be more comparable with the R^2 estimators for continuous variables (Veall and Zimmermann 1994).

When exploring the impact of NFPP on the indigenous residents' forestry income, a conditional mixed-process model was estimated to control for potential selection bias, as shown by Equations (29) and (30) below.

$$y^*_{1i} = \beta_1 x_{1i} + \varepsilon_{1i} \ ; \ y_{1i} = max\,(0, y^*_{1i}) \qquad \text{Equation (29)}$$

$$y^*_{2i} = \beta_2 x_{2i} + \varepsilon_{2i} \ ; \ y_{2i} = \begin{cases} 0, \text{ if } y^*_{2i} \le 0 \\ 1, \text{ if } y^*_{2i} > 0 \end{cases} \qquad \text{Equation (30)}$$

The explanatory variables (x_1) of forestry income (y_1) included forestland characteristics, which are complete only when the household is managing forestland ($y_2 = 1$). In other words, only the households managing forestland were incorporated into the estimation. If such a selection is systematically correlated with ε_1, $E(y_1 / x_1, x_2, y_2 = 1) \neq E(y_1 / x_1)$, then it would be inconsistent to estimate β_1 using the selected subsample (Wooldridge 2010). The mixed-process model developed to control selection bias included a binary selection equation in parallel with the forestry income equation.

Meanwhile, an endogeneity issue can still exist if the NFPP intensity (proxied by "reduction rate in SOFE timber production output") is determined by certain unobserved characteristics of the SOFEs that correlate with the income variables of indigenous residents; this is very likely to be the case and, if not controlled for, might bias the estimators of the impacts of NFPP.

For instance, suppose the true linear model is $y_i = \delta_1 x_{1i} + \delta_2 x_{2i} + u$, but x_2 is unobserved and enters the error term v ($v = \delta_2 x_{2i} + u$). In that case, when estimating the model $y_i = \delta_1 x_{1i}$ using the OLS method as if v is orthoganal to x_1 (which is actually not), the expectation of the estimator of δ_1 is given by

$$E(\tilde{\delta}_1) = \delta_1 + \delta_2 \frac{\sum_i (x_{1i} - \bar{x}_1) x_{2i}}{\sum_i (x_{1i} - \bar{x}_1)^2},$$

which is different from the δ_1 that needs to be obtained (Wooldridge 2010).

However, for this indicator of the NFPP intensity, it is difficult to control for the potential endogeneity issue due to the small amount of SOFEs in the sample. Therefore, as a robustness check, an alternative proxy of the NFPP intensity was used ("ecological forest share" of indigenous residents), and a second set of regression models (Model Set 2) were estimated to control for the potential endogeneity issue, as shown by Equations (31) through (33).

$$y_{3i}^* = \beta_3 x_{3i} + \varepsilon_{3i} \quad ; \quad y_{3i} = \begin{cases} 0, & \text{if } y_{3i}^* \le 0 \\ y_{3i}^*, & \text{if } 0 < y_{3i}^* < 1 \\ 1, & \text{if } y_{3i}^* \ge 1 \end{cases} \qquad \text{Equation (31)}$$

$$y_{4i}^* = \beta_4 x_{4i} + \gamma y_{3i} + \varepsilon_{4i} \quad ; \quad y_{4i} = \max(0, y_{4i}^*) \qquad \text{Equation (32)}$$

$$y_{5i}^* = \beta_5 x_{5i} + \varepsilon_{5i} \quad ; \quad y_{5i} = \begin{cases} 0, & \text{if } y_{5i}^* \le 0 \\ 1, & \text{if } y_{5i}^* > 0 \end{cases} \qquad \text{Equation (33)}$$

The endogeneity between "ecological forest share" (y_3) and the income variables (y_4) is reflected by assuming the interdependency of ε_3 and ε_4. The model also considered potential selection bias by modeling a binary selection variable (y_5), since "ecological forest share" can be observed only for households managing forestland. The models shown by Equations (29) – (33) were consistently estimated using the full information maximum likelihood method (Roodman 2011).

4.0 RESULTS

The regression results are presented in Tables 2–5. All the coefficients are structural and have causal interpretations, regardless whether the variable is endogenous or exogenous in the system (Schumacker and Lomax 2010; Strotz and Wold 1960).

4.1 Impacts of NFPP on Forestry Income

As shown in Table 2, the NFPP intensity indicator had negative and significant coefficients in both sets of models—which used timber production reduction as a proxy for NFPP intensity, and the other, which used "ecological forest share" as the proxy—providing evidence for the negative impacts of NFPP on the forestry income of indigenous residents. As discussed in Section 2, NFPP exerts negative impacts on forestry income by instituting direct controls on logging. However, although NFPP also enforces constraints on off-farm employment opportunities, the direction of these impacts (whether positive or negative) is difficult to predict because off-farm employment has the opposite effect on forestry income (that is, it increases income).

The empirical evidence gathered in this study indicates that the negative impacts of the logging control on forestry income outweigh the positive impacts of the off-farm employment constraints. Assuming that the indigenous residents surveyed are small-scale forestry producers faced with exogenous prices of forest products, lower forestry income is likely to imply less exploitation of forest resources. This assertion supports the conjecture that NFPP, while primarily targeted at controlling the forest use of SOFEs, has controlled the forest use of indigenous residents as well.

Table 2. Impacts of NFPP on the forestry income of indigenous residents

Dependent Variable	Model Set 1		Model Set 2		
Explanatory Variable	Forestry Income	Selection	Forestry Income	Ecological Forest Share	Selection
NFPP intensity indicator 1 (Reduction in the rate of the SOFE timber output)	−9,259.77*				
NFPP intensity indicator 2 (Ecological forest share)			−11,094.91**		
Ethnicity 2012	−385.18		−2,556.43		
Ethnicity 1997		0.68***		−0.74***	0.54**
Household size 2012	−331.81		−1,335.25**		
Household size 1997		0.14*			0.13*
Education 2012	840.55		1,137.36**		
Education 1997		0.17**			0.19***
Fixed-assets 2012	−0.03		−0.05*		
Savings 2012	−0.02		−0.02		
Value of durables 1997		+0.00		−0.00	0.00**
Off-farm workdays 1997		−0.00			−0.00
Forestland area 2012	17.20		12.37**	+0.00	
Forestland distance to house 2012	−240.44		−867.08	0.02	
Forestland soil 2012	−398.36		−136.85	0.13	
Forestland irrigation 2012	332.79		241.62	0.19	
Forestland slope 2012	1,203.64		2,354.33	0.60***	
Land area 1997		0.03***		0.00	0.01**
Performance of village leaders 1997–2012		−0.05			−0.00
Yunnan	9,232.14**	0.36	7,329.17**	−1.79***	0.50**
Constant	−7,693.10	−0.73	−3,439.39	0.06	−0.92*
Wald test of model significance (p-value)	0.00		0.00		
Observations	210		300		

Note: *, **, and *** respectively indicate statistical significance at the 10%, 5%, and 1% levels.

However, there was no clear evidence to support the conjecture that NFPP has heterogeneous impacts across ethnic groups, since the coefficient of "ethnicity" was insignificant in both models. The coefficients of some other explanatory variables were significant in at least one of the two models. Households with more members had lower forestry income per capita. Although the number of income-earning members is likely to be similar across households, a larger household size implies the presence of more nonlabor members (children and elderlies). The coefficient of productive fixed-assets was negative in both models, which may be because forestry production involves less input of fixed-assets in the study areas, and a higher endowment of productive fixed-assets may imply more weight of other production activities in the livelihood portfolio. Unsurprisingly, education and forestland area had positive impacts on forestry income.

The equation "ecological forest share" controlled the potential endogeneity issue of the NFPP intensity and explored what types of households are likely to face more stringent implementation of NFPP. According to the regression results, ethnic minority households are likely to face less stringent implementation of NFPP, which is probably because the enforcement of NFPP has been compromised by their constitutional rights to maintain their traditional customs involving forest tenure arrangements and forest use. Households with more steeply sloped forestlands are likely to face more stringent implementation of NFPP, since highly sloped forestland is one of the conservation priorities of the program so as to provide additional watershed services and mitigate soil erosion, landslides, and other geologic disasters.

The “selection” equations controlled for the potential selection issue, since only the forest-managing households were included in estimating the equation “forestry income.” The regression results of the “selection” equations also reflected the factors that influenced whether a household is managing any forestland. The regression results were highly consistent in the two models, in terms of the direction (positive/negative), magnitude, and statistical significance of the estimated coefficients of the explanatory variables. According to these results, ethnic minority households are more likely to manage forestland, reflecting a potential preferential treatment during the collective forestland allocation. Households with more members and who had larger land area in 1997 are more likely to manage forestland, since the amount of household members is usually an important criterion when allocating the collective land (both cropland and forestland) in rural China. In addition, better-educated households are more likely to manage forestland.

4.2 Impacts of NFPP on Agricultural Income

Table 3 shows that the NFPP intensity indicator has positive and significant coefficients in both sets of models, supporting the hypothesis that NFPP has increased the agricultural income of indigenous residents. Assuming that these indigenous residents are small-scale agricultural producers faced with predetermined prices of agricultural products, higher agricultural income is likely to imply a more intensive use of cropland and other agricultural inputs, such as irrigation water and chemical fertilizer. The findings therefore support the conjecture that NFPP, by controlling forest use, has caused environmental leakage impacts through the intensification of agricultural production.

As for the other influencing factors of agricultural income, the study results show that ethnic minority households are likely to have lower agricultural income, whereas households with larger land area are likely to have higher agricultural income. The regression results of “ecological forest share” and “selection” equations are similar with the counterparts of the “forestry income” models.

Table 3. Impacts of NFPP on the agricultural income of indigenous residents

Dependent Variable	Model Set 1		Model Set 2	
Explanatory Variable	Agricultural Income	Agricultural Income	Ecological Forest Share	Selection
NFPP intensity indicator 1 (Reduction in the rate of the SOFE timber output)	2,870.32*			
NFPP intensity indicator 2 (Ecological forest share)		6,653.68**		
Ethnicity 2012	–2,363.21***	–953.22		
Ethnicity 1997			–0.73***	0.27
Household size 2012	–209.29	–411.37		
Household size 1997				0.13*
Education 2012	170.36	–91.02		
Education 1997				0.19***
Fixed-assets 2012	0.01	–0.00		
Savings 2012	–0.01	0.01		
Value of durables 1997			–0.00	+0.00
Off-farm workdays 1997				–0.00
Forestland area 2012			+0.00	
Forestland distance to house 2012			–0.01	
Forestland soil 2012			0.07	
Forestland irrigation 2012			0.16	
Forestland slope 2012			0.53***	
Land area 2012	8.97**	0.60		
Land area 1997			+0.00	0.02***
Land distance to house 2012	–105.00	–12.68		

Table 3 continued

Dependent Variable	Model Set 1		Model Set 2	
Explanatory Variable	Agricultural Income	Agricultural Income	Ecological Forest Share	Selection
Land soil 2012	182.75	298.64		
Land irrigation 2012	831.30	1,167.84		
Land slope 2012	–124.61	–796.70		
Performance of village leaders 1997–2012				+0.01
Yunnan	3,376.21***	4,248.06***	–1.73***	0.60**
Constant	–3,592.03	–3,449.91	0.33	–0.85
Wald test of model significance (p-value)	0.01		0.00	
R^2	0.24			
Observations	210		300	

Note: *, **, and *** respectively indicate statistical significance at the 10%, 5%, and 1% levels.

4.3 Impacts of NFPP on Off-Farm Income

The regression results of the "off-farm income" models did not provide any clear evidence of the impacts of NFPP on the off-farm income of indigenous residents, as shown by Table 4. However, the increase in agricultural income from 1997 to 2012 suggests the constraint on off-farm employment opportunities. Results seemed to show that the NFPP constraints on off-farm employment do not equate to lower off-farm income/labor supply. In the theoretical model in Section 2, the off-farm employment ceiling ($\bar{T}^O$) did not have to be lower than the original optimized off-farm labor supply (T^{O*}) to make the total income lower after the implementation of NFPP; this is discussed in a later part of this report. It can be shown that the total income would decrease if ($\bar{T}^O$) is no greater than the optimized off-farm labor supply when only the logging control is imposed ($\hat{T}^O$). The regression results of the "off-farm income" are therefore not inconsistent with the theoretical predictions.

The coefficients of other explanatory variables of off-farm income were significant in at least one of the two models. Ethnic minority households had lower off-farm income, which is probably because the language difference has limited their off-farm job opportunities outside their own communities. According to the regression results, if the land of a household is located near the house, or if the land can remain productive even when not irrigated, then this household is likely to have higher off-farm income. Education, savings, and productive fixed-assets had positive impacts on off-farm income.

Table 4. Impacts of NFPP on the off-farm income of indigenous residents

Dependent Variable	Model Set 1	Model Set 2		
Explanatory Variable	Off-farm Income	Off-farm Income	Ecological Forest Share	Selection
NFPP intensity indicator 1 (Reduction in the rate of SOFE timber output)	1,459.23			
NFPP intensity indicator 2 (Ecological forest share)		–3,904.70		
Ethnicity 2012	–471.17	–2,195.37		
Ethnicity 1997			–0.83	0.32
Household size 2012	–437.99	–305.20		
Household size 1997				0.15
Education 2012	1920.13	1,289.38		
Education 1997				0.18
Fixed-assets 2012	0.02	+0.00		

Table 4 continued

Dependent Variable	Model Set 1	Model Set 2		
Explanatory Variable	Off-farm Income	Off-farm Income	Ecological Forest Share	Selection
Savings 2012	0.01	0.01		
Value of durables 1997			–0.00	+0.00
Off-farm workdays 1997				–0.00
Forestland area 2012			+0.00	
Forestland distance to house 2012			–0.00	
Forestland soil 2012			0.10	
Forestland irrigation 2012			0.14	
Forestland slope 2012			0.60	
Land area 2012	–1.67	–0.47		
Land area 1997			0.00	0.01
Land distance to house 2012	–1,173.03	–639.09		
Land soil 2012	1,019.90	1,159.21		
Land irrigation 2012	–12,348.77	–924.61		
Land slope 2012	703.98	87.87		
Performance of village leaders 1997–2012				–0.02
Yunnan	–758.83	–3,826.59	–2.01	0.58
Constant	13,275.17	8,808.83	0.64	–0.76
Wald test of model significance (p-value)	0.01	0.00		
R^2	0.16			
Observations	210	300		

Notes: *, **, and *** respectively indicate statistical significance at the 10%, 5%, and 1% levels

4.4 Impacts of NFPP on Total Income

The impacts of NFPP on the foregoing income components add up to the impacts on total income, as shown in Table 5. The regression results support the hypothesis that NFPP has caused negative impacts on the total income of indigenous residents, although the finding is significant in Model Set 2 only. Based on the theoretical predictions and the variations of the income components, the total income loss can be attributed to the logging control and off-farm employment constraints imposed by NFPP. These findings indicate that the welfare impacts of NFPP have spilled over from SOFE employees onto indigenous residents.

The study also found that ethnicity minority households are likely to have lower income, in spite of the preferential treatments they seem to be enjoying during the implementation of NFPP. Larger households are likely to have lower per capita income, which is probably due to more nonlabor members indicated by a bigger household size. In addition, results show that if a household has received better education, has more land, or has more fixed-assets, the household is likely to have higher income.

Table 5. Impacts of NFPP on the total income of indigenous residents

Dependent Variable	Model Set 1	Model Set 2		
Explanatory Variable	Total Income	Total Income	Ecological Forest Share	Selection
NFPP intensity indicator 1 (Reduction in the rate of the SOFE timber output)	−1,077.28			
NFPP intensity indicator 2 (Ecological forest share)		−4,072.32***		
Ethnicity 2012	−635.59	−3,194.78***	−0.92***	
Ethnicity 1997				0.37**
Household size 2012	−967.13***	−1,405.58***		
Household size 1997				0.10*
Education 2012	1,050.74**	760.05**		
Education 1997				0.10**
Fixed-assets 2012	0.01	0.01***		
Savings 2012	−0.00	0.01		
Value of durables 1997			−0.00***	+0.00*
Off-farm workdays 1997				−0.00
Forestland area 2012			+0.00*	
Forestland distance to house 2012			0.01	
Forestland soil 2012			0.05	
Forestland irrigation 2012			0.26	
Forestland slope 2012			0.56***	
Land area 2012	4.71	9.53***		
Land area 1997			+0.00	0.01*
Land distance to house 2012	−302.62	270.66		
Land soil 2012	683.39	616.31		
Land irrigation 2012	−4,922.62	951.65		
Land slope 2012	601.67	−2.07		
Performance of village leaders 1997–2012				−0.02
Yunnan	2,882.07**	−54.35	−2.06***	0.68***
Constant	14,313.65***	16,470.21***	0.80*	−0.40
Wald test of model significance (p-value)	0.00	0.00		
R^2	0.15			
Observations	210	300		

Note: *, **, and *** respectively indicate statistical significance at the 10%, 5%, and 1% levels.

5.0 CONCLUSION

It is often conjectured that conservation policies for state-owned forests not only influence the state employees managing these forests, but also cause leakage effects on the indigenous residents living in state forest regions. This research explored this conjecture by conducting a case study on NFPP, a large-scale forest conservation program primarily targeted at state-owned forests in China. This study was conducted under the context of the state forest regions in Gansu and Yunnan provinces in Western China. NFPP was interpreted as a logging control and a constraint on off-farm employment opportunities imposed on indigenous residents, since SOFEs used to serve as an important source of off-farm jobs. However, the off-farm labor demand for indigenous residents has substantially decreased after NFPP was implemented.

A theoretical model was developed as part of this study to describe the mechanism as to how NFPP influences the labor allocation and production decisions of indigenous communities, which would eventually affect their income components and total income. The theoretical predictions were subsequently examined through the use of empirical analyses based on micro-data collected from 300 indigenous households. Using alternative indicators of the NFPP intensity and rigorous econometric methods that controlled for potential selection and endogeneity issues, the authors were able to generate reasonable causality inferences about the impacts of NFPP.

Both the theoretical predictions and empirical results revealed that NFPP negatively impacts the forestry income of indigenous residents, implying that the program has curbed their forest use. Although the primary objective of NFPP is to restrict the excessive exploitation of forest resources in state forest regions, the long-term viability of the program is brought into question by the decreased total income of indigenous communities as indicated by both the theoretical predictions and empirical results. Furthermore, being subject to the constraints imposed by NFPP and due to the lack of alternative livelihood sources in the surveyed regions, indigenous residents seem to have responded to forest income losses by intensifying agricultural production activities. This suggests that NFPP has probably caused environmental leakage effects by switching the environmental pressure from forests to cropland. This finding aligns with existing studies on environmental leakage effects of conservation programs (e.g., Alix-Garcia, Shapiro, and Sims 2012; Pfaff and Robalino 2012; Wu 2000), although these studies focused on the exploitation of natural resources outside the conserved regions.

The empirical results of this study also show that ethnic minority households in the surveyed regions are likely to face less stringent implementation of NFPP, attributed to their constitutional rights to maintain their traditional customs, many of which involve forest tenure arrangements and forest use. This supports the evidence for the heterogeneous impact of NFPP across different ethnic communities.

Overall, these findings support the hypothesis that forest conservation policies for state-owned forests can influence unofficial stakeholders as well. In this respect, the findings of this research are consistent with previous studies on the impact of protected area-akin programs on unofficial stakeholders living in program regions (e.g., Andam et al. 2010; Sims 2010; Watson et al. 2014; West, Igoe, and Brockington 2006). However, the particular impact identified in these studies varies from one case to another.

Therefore, the influencing factors identified in this research need to be considered when designing prospective institutional reforms in state forest regions; unofficial stakeholders, such as indigenous communities, also need to be taken into account in policy decisions. Under the particular context of the surveyed regions, indigenous communities, while facing more stringent implementation of NFPP, would tend to have limited alternative livelihood sources. It is thus advisable to either provide substantial compensation for these indigenous communities or relax the constraints imposed on them by NFPP (Xu, Jiang, and Ji 2006). As a prerequisite of these policy remedies, forest tenure arrangements ought to be formalized among SOFEs, SOFE employees, and indigenous communities located in state forest regions. This will contribute to the long-term efficacy of conservation policies as well as mitigate the conflicts among these stakeholders over contested use of forest resources.

As mentioned previously, the authors collected samples in state forest regions only and then used NFPP intensity indicators to examine the impacts of the program, instead of constructing treatment and control groups by comparing households living inside state forest regions with those living elsewhere. This empirical strategy had its intrinsic merits, such as avoiding the potential compound treatments (e.g., the joint treatment of NFPP and state ownership of forests). However, this empirical strategy could provide only estimates of the impacts of NFPP implemented at different levels of intensity (within a certain range), instead of the impacts of program establishment compared to the lack of one.

This study also explored the environmental leakage effects of NFPP by evaluating the impacts of the program on the different income components in order to reflect the labor allocation mechanism behind the leakage effects. As such, this study could provide only inferences about the environmental leakage effects, instead of providing direct evidence of natural resource use. Note that these findings were made under the particular context of the state forest regions in western areas of China, most of which are remote mountainous areas where alternative livelihood sources are limited. In spite of the environment and development significance of these regions, we should be cautious about generalizing the findings of this study to other state forest regions with different institutional settings. For instance, negative livelihood impacts of NFPP were not identified by some existing studies focused on other regions due to the positive substitution effects from forestry to off-farm work (Mullan et al. 2010). Therefore, the findings of this study should be interpreted under the context of the empirical strategies and the local settings.

LITERATURE CITED

Alix-Garcia, J.M.; E.N. Shapiro; and K.R.E. Sims. 2012. Forest conservation and slippage: Evidence from Mexico's national payments for ecosystem services program. Land Economics. 88(4): 613–638.

Andam, K.S.; P.J. Ferraro; K.R.E. Sims; A. Healy; and M.B. Holland. 2010. Protected areas reduced poverty in Costa Rica and Thailand. Proceedings of the National Academy of Sciences. 107(22): 9996–10001.

Angelsen, A. 2001. Playing games in the forest: State-local conflicts of land appropriation. Land Economics. 77(2): 285–299.

Besley, T. 1995. Property rights and investment incentives: Theory and evidence from Ghana. Journal of Political Economy. (103)5: 903–937.

Bulte, E. and S. Engle. 2006. Conservation for tropical forests: Addressing market failure. R. López and M.A. Toman (ed) *In* Economic development and environmental sustainability: New policy options. Oxford University Press, New York, USA. 412–453.

Bulte, E.; N. Heerink; and Zhang X. 2011. China's one-child policy and 'the mystery of missing women': Ethnic minorities and male-biased sex ratios. Oxford Bulletin of Economics & Statistics. 73(1): 21–39.

Cao S.; Wang X.; Song Y.; Chen L.; and Feng Q. 2010. Impacts of the Natural Forest Conservation Program on the livelihoods of residents of Northwestern China: Perceptions of residents affected by the program. Ecological Economics. (69)7: 1454–1462.

Engel, S.; C. Palmer; and A. Pfaff. 2013. On the endogeneity of resource comanagement: Theory and evidence from Indonesia. Land Economics. 89(2): 308–329.

Ferris, J.; and J. Siikamäki. 2009. Conservation reserve program and wetland reserve program: Primary land retirement programs for promoting farmland conservation. Resources for the Future. Washington, D.C., USA.

Gertler, P.J.; S. Martinez; P. Premand; L.B. Rawlings; and C.M.J. Vermeersch. 2011. Impact evaluation in practice. The World Bank. Washington, D.C., USA.

Groom, B.; P. Grosjean; A. Kontoleon; T. Swanson; and Zhang S. 2010. Relaxing rural constraints: A 'win-win' policy for poverty and environment in China? Oxford Economic Papers. 62(1): 132–156.

Hares, M. 2009. Forest conflict in Thailand: Northern minorities in focus. Environmental Management. 43(3): 381–395.

Hasmash, R. 2009. Dealing with urban ethnic differences: A comparative analysis of Chinese and Canadian strategies. H. Cao (ed) *In* Ethnic minorities and regional development in Asia: Reality and challenges. Amsterdam University Press, Amsterdam, The Netherlands. 93–109.

Haughton, J. and S.R. Khandker. 2009. Handbook on poverty and inequality. The World Bank. Washington, D.C., USA.

Holden, S. and H. Yohannes. 2002. Land redistribution, tenure insecurity, and intensity of production: A study of farm households in Southern Ethiopia. Land Economics. 78(4): 573–590.

Huffman, W.E. 1980. Farm and off-farm work decisions: The role of human capital. Review of Economics & Statistics. 62(1): 14–23.

Jiang X.; P. Gong; G. Bostedt; and Xu J. 2014. Impacts of policy measures on the development of state-owned forests in northeast China: Theoretical results and empirical evidence. Environment and Development Economics. 19(1): 74–91.

Katsigris, E. 2002. Local-level socioeconomic impacts of the Natural Forest Protection Program. Xu, J.; E. Katsigris; and T.A. White (ed) *In* Implementing the Natural Forest Protection Program and the Sloping Land Conversion Program: Lessons and policy recommendations. China Forestry Publishing House, Beijing, China.

Liu C.; Lu J.; and Yin R. 2010. An estimation of the effects of China's priority forestry programs on farmers' income. Environmental Management. 45(3): 526–540.

Liu J.; Li S.; Ouyang Z.; Tam C.; and Chen X. 2008. Ecological and socioeconomic effects of China's policies for ecosystem services. Proceedings of the National Academy of Sciences. 105(28): 9477–9482.

Liu T.; Liu C.; Liu H.; Wang S.; Rong Q.; and Zhu W. 2014. Did the key priority forestry programs affect income inequality in rural China? Land Use Policy. 38(May): 264–275.

Mullan, K.; A. Kontoleon; T. Swanson; and Zhang S. 2010. Evaluation of the impact of the Natural Forest Protection Program on rural household livelihoods. Environmental Management. 45(3): 513–525.

National People's Congress. 2002. Law of the People's Republic of China on land contract in rural areas. http://www.gov.cn/english/laws/2005-10/09/content_75300.htm (Retrieved 14 September, 2014).

Nielsen, Ø. J.; S. Rayamajhi; P. Uberhuaga; H. Meilby; and C. Smith-Hall. 2013. Quantifying rural livelihood strategies in developing countries using an activity choice approach. Agricultural Economics. 44(1): 57–71.

Pfaff, A. and J. Robalino. 2012. Protecting forests, biodiversity, and the climate: Predicting policy impact to improve policy choice. Oxford Review of Economic Policy. 28(1): 164–179.

Poverty Environment Network. 2007. The poverty environment network technical guidelines. http://www1.cifor.org/pen/research-tools/the-pen-technical-guidelines.html (Retrieved 14 September, 2014).

Roodman, D. 2011. Fitting fully observed recursive mixed-process models with cmp. Stata Journal. 11(2): 159–206.

Rossi, P.H.; M.W. Lipsey; and H.E. Freeman. 2004. Evaluation: A systematic approach (7th ed.). SAGE Publications, Inc., Thousand Oaks, USA.

Schumacker, R.E. and R.G. Lomax. 2010. A beginner's guide to structural equation modeling (3rd ed.). Routledge, New York, USA.

Sims, K.R.E. 2010. Conservation and development: Evidence from Thai protected areas. Journal of Environmental Economics and Management. 60(2): 94–114.

Singh K. 1999. Rural development: Principles, policies and management (2nd ed.). SAGE Publications, Inc., Thousand Oaks, USA.

Spignesi, S.J. 2004. Catastrophe! The 100 greatest disasters of all time. Kensington Publishing Corporation, New York, USA.

Strotz, R.H. and H.O.A. Wold. 1960. Recursive vs. nonrecursive systems: An attempt at synthesis (Part I of a triptych on causal chain systems). Econometrica. 28(2): 417–427.

Sunderlin, W.D.; J. Hatcher; and M. Liddle. 2008. From exclusion to ownership? Challenges and opportunities in advancing forest tenure reform. The Rights and Resources Initiative, Washington, D.C., USA.

The State Council. 2000. National minorities policy and it's practice in China. http://www.china.org.cn/e-white/4/ (Retrieved 14 September, 2014).

The State Forestry Administration. 1998. China forestry statistical yearbook 1998. China Forestry Publishing House, Beijing, China.

——— . 2012. China forestry statistical yearbook 2012. China Forestry Publishing House. Beijing, China.

Veall, M.R. and K.F. Zimmermann. 1994. Practitioners corner: Goodness of fit measures in the Tobit model. Oxford Bulletin of Economics and Statistics. 56(4): 485–499.

Wang Y. 2010. Social impact assessment of the Natural Forest Protection Program on the forest-dependent communities and households in Western China - Case studies in Gansu Province and Chongqing Municipality. Technische Universität Dresden. PhD dissertation.

Watson, J.E.M.; N. Dudley; D.B. Segan; and M. Hockings. 2014. The performance and potential of protected areas. Nature. 515(7525): 67–73.

West, P.; J. Igoe; and D. Brockington. 2006. Parks and peoples: The social impact of protected areas. Annual Review of Anthropology. 35(October): 251–277.

Weyerhaeuser, H.; A. Wilkes; and F. Kahrl. 2005. Local impacts and responses to regional forest conservation and rehabilitation programs in China's northwest Yunnan province. Agricultural Systems. 85(3): 234–253.

White, A. and A. Martin. 2002. Who owns the world's forests? Forest tenure and public forests in transition. Forest Trends. Washington, D.C., USA.

Wooldridge, J.M. 2010. Econometric analysis of cross section and panel data (2nd ed.). The MIT (Massachusetts Institute of Technology) Press, Cambridge, USA.

Wu J. 2000. Slippage effects of the Conservation Reserve Program. American Journal of Agricultural Economics. 82(4): 979–992.

Xie Y.; Wen Y.; Zhang Y.; and Li X. 2013. Impact of property rights reform on household forest management investment: An empirical study of southern China. Forest Policy and Economics. 34(September): 73–78.

Xu J.; Jiang X.; and Ji Y. 2006. Empirical study of reform and development in the key state-owned area. The Chinese Journal of Forestry Economics. 1: 10–15.

Xu J.; A. White; and U. Lele. 2010. China's forest tenure reforms: Impacts and implications for choice, conservation, and climate change. The Rights and Resources Initiative. Washington, D.C., USA.

Xu J.; Yin R.; Li Z.; and Liu C. 2006. China's ecological rehabilitation: Unprecedented efforts, dramatic impacts, and requisite policies. Ecological Economics. 57(4): 595–607.

Xu J.; Yu Y.; Xie C.; Li C.; Chen B.; Cou L. 2003. The Natural Forest Protection Program has a great impact on the development of collective forest and community economy. The Chinese Journal of Forestry Economics. 6: 28–32.

Yasmi, Y.; L.C. Kelley; and T. Enters. 2013. Community-outsider conflicts over forests: Perspectives from Southeast Asia. Forest Policy and Economics. 33(August): 21–27.

Zhu K. 2012. A case for farmers and rural communities' right to compensation under China's Natural Forest Protection Program. The Rights and Resources Initiative, Washington, D.C., USA.

Strengthening local capacity in the economic analysis of environmental issues

Recent EEPSEA Research Reports

Using Reservoirs to Adapt to Drought in Agriculture: A Cost-Benefit Analysis from Cambodia
Chhinh Nyda, Cheb Hoeurn, Chea Bora, and Heng Naret
2014-RR8

Estimating the Impact of Weather Shocks on Agricultural Production and Migration in China
Yazhen Gong
2015-RR9

Downscaling REDD Policies in Developing Countries: Assessing the Impact of Carbon Payments on Household Decision Making and Vulnerability to Climate Change in Vietnam
Pam McElwee, Nghiem Phuong Tuyen, Le Hue, and Vu Huong
2015-RR10

A Cost-Benefit Analysis of Dike Heightening in the Mekong Delta
Tong Yen Dan
2015-RR11

Assessment of Natural Assets in the Agricultural and Aquatic Ecosystems in Sogod Bay, Southern Leyte
Ma. Salome B. Bulayog, Humberto R. Montes, Jr., Suzette B. Lina, Teofanes A. Patindol, Adelfa C. Diola, Eliza D. Espinosa, Analyn M. Mazo, Julissah C. Evangelio, Art Russel R. Flandez, Marianne A. Gesultura, and Ris Menoel R. Modina
2015-RR12

Fiscal Gap and Financing of Southeast Asia's Protected Areas: A Cross-Country Analysis
Gem Castillo
2015-RR13

Farmers' Adaptation to Climate Change and Their Risk Preferences in Yongqiao District, China
Jin Jianjun, Gao Yiwei, Wang Xiaomin, and Pham Khanh Nam
2015-RR14

Cost-Benefit Analysis of the Introduction of the Indonesian Sustainable Palm Oil Standards: A Case Study in Jambi Province, Indonesia
Ernah
2015-RR15

Estimating the Economic Impacts of Climate Change on Crop Production in the Coastal Provinces of the Mekong Delta, Vietnam
Le Thi Diem Phuc, Vo Duc Hoang Vu, and Huynh Thi Dan Xuan
2015-SRG1

Leadership in Solving Social Dilemmas: An Experiment in Mekong Delta, Vietnam
Truong Cong Thanh Nghi, Ngo Hoang Thao Trang, and Trinh Van Hop
2015-SRG2

Willingness to Pay or Willingness to Accept: Determining the Appropriate Welfare Measure when Prefence is Reference-Dependent
Jack L. Knetsch and Phumsith Mahasuweerachai
2015-RR16

Willingness to Pay or Willingness to Accept: Determining the Appropriate Welfare Measure when Prefence is Reference-Dependent
Jack L. Knetsch and Phumsith Mahasuweerachai
2015-RR16

Environmental Satisfaction among Residents in Chinese Cities
Wang Chunhua and Zhang Changdong
2015-RR17

Using Feedback as a Tool for Household Energy Conservation: An Experimental Approach
Kannika Thampanishvong
2015-RR18

The Impact of VietGAP Vegetable Production on the Health of Farmers in Thua Thien Hue Province, Vietnam
Tran Huynh Bao Chau and Le Thi Quynh Anh
2015-RR19

Who Walks in the Shadows? Revealing the Blind Spots of the Natural Forest Protection Programme in China
Liu Zhaoyang, Andreas Kontoleon, and Xu Jintao
2015-RR20

EEPSEA is administered by WorldFish on behalf of its donors, Sida and IDRC.

Sida

IDRC CRDI