Introduction

Hainan Island, which covers a total area of 3.4 million ha, is located in the South China Sea and separated from the Chinese mainland by the Qiongzhou Straits. It is almost as large as Taiwan Island. Comparatively, it has a shorter history and the economy was more isolated and less developed in China. However, since 1988 when the island was upgraded into provincial level and given a status of Special Economic Zone (which has more free market and with government intervention), both the economy and population have dramatically changed.

Hainan has a typical tropical monsoon climate. Originally, it was covered mostly by rainforests (Situ 1992), but the effect of long-term human activities has caused serious deforestation and degradation of forestland. Compared with the forest change in history, recent changes are more dramatic. The rainforest still covered 50% of the island in the early 1930s, but at the beginning of the 1950s only left about 30% and the remaining forests were mostly located in the center of mountain ranges (HAZC 1980). In the late 1970s, forest cover further declined to only 15%, even including plantation forests. Consequently, Hainan changed from being a net timber exporter in the 1950s-1970s to an importer in the 1980s.
Fortunately, during the last two decades the decreasing trend in forestland area has been reversed and forest area in Hainan is presently expanding (see Figures 1–2).

![Figure 1: Forest coverage/inventory (1950s-1990s)](image1)

![Figure 2: Timber production (1950s-1990s)](image2)

The slow change of forest before the 1930s was due to its isolated location that had less influence beyond the region. The dramatic decline from the 1930s to the 1970s and substantial increase since 1980s can be explained largely by forces beyond the region and extra-sectoral economy and policies. The change also provides empirical support for the ‘forest transition’ hypothesis claiming that the declining forestland area will eventually begin to increase as the country develops as suggested in Mather (1990), Hyde et al. (1996), Rudel (1998) and Zhang (2000) among others.

This article uses the case of Hainan to examine the impacts on market and institution on deforestation and reforestation. First, the general the extra-region and extra-sectoral driving forces of deforestation and forest transition, i.e. forces coming outside Hainan and from other sectors than forestry are discussed, then econometric analyses are applied to examine their impacts. Policy implication and discussion are presented at the end. We believe that our conclusions will be applicable to the rest of China, and also to many developing countries the economies in transition. We also expect that our results complement those of other studies.
that have focused more on policies within the forestry sector. Hainan island is a ideal place to examine the role of market and institution on deforestation and reforestation since all these have happened significantly in relatively short period of time.

**The Intra and Extra-Sectoral Impacts: the Role of Market and Institutions**

As in the rest of the tropical world, in a long historical perspective deforestation in Hainan was directly caused by logging, shifting cultivation, agricultural land encroachment and residential and industrial expansion, and indirectly affected by the socio-economic and institutional factors. Due to the difficulties in transportation for the isolated island and less accessibility of rainforest for the special topography of the island, the forests were less impacted by the economic factors and economic policies beyond the island before 1933.

The first biggest external impact on Hainan forest was the Japanese occupation during the 1930s. Large-scale timber extraction had been conducted by the four big Japanese logging firms with 1500 workers. Annual timber production was estimated more than 10,000 m$^3$. In addition, eighteen wood processing firms were set up at that time (Chen 1948). During the war period, huge amount of timber was extracted for road construction and for war preparation purposes and destroyed by forest fires.

The policy changes that had most significant impacts on forestry were the Land Reform implemented in 1950-1956, and socialistic transformation and People’ Commune. During land reform all land owned by landlords was confiscated and most of it distributed to local farmers. However, remote areas, particularly in the central island, i.e. the rainforests, were reallocated to the state-owned logging firms. In socialistic transformation that started in 1957 the land was transferred from individuals back to the collectives in the first phase of collectivization, and then to the People’s Communes in the second phase.

The impacts on forestry from the land reforms probably are reflected from three aspects. First, the change in institutions that had governed property rights and increasing uncertainty for the landowners has far-reaching negative impact on forestry. Second, the decline of agricultural productivity under the people’s Commune required larger agricultural land to produce sufficient food supply. Third, the enlarging state-owned land increased the state
control on the land and forests: during the 1950s and 1960s, about 350 000 ha of forestry land was allocated to state logging firms, of which 80% went to the 11 largest ones (HAZC 1980). The accumulative timber extraction from 1955 to 1991 amounts to 3 million m$^3$, accounting for 70% of the total industrial timber production in Hainan. About 40 000 – 60 000 m$^3$ of tropical log was flow annually to outside the island during the late 1950s to the early 1970s. It is documented 40000 ha of rainforest had been logged by the end of 1980s. Since most of the harvesting was conducted by clear-cutting, and often repeated, the harvested sites often shifted to degraded shrubs or even bareland.

Hainan, accounting for a significant part of tropical region for China, is important for some agricultural products, such as rubber. Tropical crops were introduced in Hainan at the beginning of this century, but it was not until 1950s they started to expand dramatically because of increasing domestic demand for natural rubber materials (trade was blocked by the western world at that time). Like the State-Owned Logging Firms (SOLF$s$), a large scale of Farm Reclamation System (FRS) was set up, attempting to plant rubber trees. About 0.85 million ha, accounting for 25% of the total island were allocated to the state-owned farms under the FRS. The population under this system reached 1 million, accounting for 20% in the 1970s. This is probably the biggest extra-sectoral impact on forestry in the past half century. From 1955 to 1980, about 450 000 ha of natural forests administrated by FRS had declined to less than 100 000 ha in 1980 (Yi 1980).

Over the four decades, permanent agricultural land has not expanded significantly, but shifting cultivation, which has been widely practiced by local minorities, has destroyed large tracts of rainforest. The shifting cultivation was most serious during the food shortage period.
It is estimated that 2 700 ha of forests were destroyed annually in the 1970s-1980s (Bao 1991). After three decades of destruction, the forests shrank to their minimum level, 15% of total land area, in the late 1970s (HAZC 1980).

The economic reform, started in the late 1970s, has had a far-reaching impact on forest. The impacts not only reflect in forestry and agriculture, but also the indirect impacts from the economic growth and population migration. The most significant reform in agriculture and forestry has been the introduction of the Household Responsibility System (HRS), which actually represents a kind of privatization of land use rights, or labor use rights. In the forest sector, the reform in general began a little later and is far less intensive and extensive than in agriculture (Zhang et al. 1999). The institutional reforms in Hainan forestry sector during the last 20 years were reflected in the changes of land tenure and forest management organization. The innovative organization in plantation forest adopted is the “Joint plantation of fast-growing species of trees”.¹ HRS has been extensively introduced in “Closed access management of degraded forestry land”². The impact of HRS in agriculture is shown in increasing productivity and efficiency, which indirectly reduced the pressure on forest land. In forestry, it is shown in property right clarification and reduces the uncertainty.

¹ In the late 1970s, the Ministry of Forestry started planning to establish 130 000 ha of fast-growing trees in Hainan. A project, referred to as “2 million mu (15 mu = 1 ha) joint plantation of fast-growing and high-yield species of trees”, was formally launched in 1982. The joint partners were the Ministry of Forestry, which provided the capital, the local collectives, which provided the land, and the local people, who supplied labor. Encouraged by this initiative, several other joint plantation projects followed. A few banks, including the World Bank, provided substantial loans for these projects.

² Closed access management, which has been mainly applied to degraded forestry land, has greatly accelerated its rehabilitation. Exclusiveness is a pre-requisite for silvicultural investment (Zhang and Pearse 1996). In Hainan, contracts between the local collectives, who own the land and trees, and households, who receive an annual guardian fee or share of the return from the final harvests have been used to reduce the costs of exclusion. Thus, this arrangement individualizes some of the benefits from enforcement of the forestland property rights at low costs, serving as a kind of privatization. During the 1980s, it was estimated that more than 100 000 ha of degraded land had been rehabilitated in Hainan by this approach (Zeng 1994), and almost the same area during the 1990s. Therefore, 6-8% of the total territory has been reforested by this method.
The most fundamental reasons for the forest transition probably are generated from the economic growth that is contributed by the economic reform and open policy since the late of 1970s. In 1988, Hainan was upgraded to the provincial level and given the status of Special Economic Zone. Since then, the economic growth rate, averaging 20% annually from 1988 to 1995, has been the fastest at provincial level in China. The population is also growing dramatically, from 5 million in the mid-1980s to 8 million at present (the actual population could be over 10 million).

The fast economic growth creates effective demand for environmental goods. Restrictions have gradually been imposed on rainforests. First, only selective cutting was allowed in the late 1970s. Then, a quota of allowable fellings was set in 1984 and has been gradually reduced since then. Finally, in principle, harvesting of all rainforest has been banned since 1993 and 1994. Therefore, the rainforest area has stabilized.

The economic reforms also promote the international timber trade, especially the wood-chip export. A total of 130 000 ha of eucalyptus and some other fast growing species of trees was planted between 1982 and 1995, accounting for more than one third of plantation forests during this period, and contributed to a 4% increase in total forest cover. The wood-chip export is the most important force for the plantations. From 1989 to 2000, about 1 million tones of wood-chip have been exported, which is larger than the tropical timber flow outside the Island in the past several decades. Since 1990, income from wood-chip exports has become an important source of foreign currency earnings and an important part of rural economy.

To empirically examine the impacts of demographic and socio-economic factors (the market and institution), including intra and extra-sectoral sectors, on forest, the following section present the results of an econometric analysis that has been conducted using the empirical material on forest area development in Hainan.

Econometric Analysis

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3 The results have been published in Canadian Journal of Forestry Research 30: 1913–1921
We use forest land change as a major indicator to study the impacts on forestry. Theoretically, the land allocation to forest is determined by the relative prices across the output prices if we ignore the input factors:

(1) \[ A_i^* = (p, c, A) \]

where \( A_i^* \) is the land allocated to land use \( i \), \( p \) is the vector of product prices, \( c \) is the composite input cost. \( A \) is the total available land area. The optimal land allocation functions, the \( A_i^* (p, c, A) \), are nondecreasing in \( p_i \) (i=j). It can be shown that the cross-price effects are nonpositive (see Zhang et al 2000). For the purposes of the empirical modeling, these results give us the expected positive sign for the effect of a change in timber price on the amount of land allocated for forest, and an expected negative sign for the cross-price effects of the various land use classes. The effect of \( c \) on \( A_i^* (p, c, A) \) depends on the substitution effect between land and the aggregate input, plus the output effect. A priori the total effect of \( c \) is indeterminate.

As we argue, besides markets and prices, institutional factors play a key role in rural land allocation in Hainan. Therefore, we include in the forest land allocation model variables describing the economic development and population, as well as two variables describing the land property rights policies in China. The first two variables are gross output value (GOP) and population density (PD) in each of the Hainan counties.\(^4\)

The land reform variables are the percentage share of land under the household-responsibility system (H), and the percentage of forestry land under state ownership (SF). These variables thus measure the effects of land-tenure shift and decentralization of forestland management in Hainan. Accounting for the market-driven and the institutional factors, the implicit model for forestland allocation within the counties in Hainan can be written as:

(2) \[ Forestland Allocation = F (p, c, A; GOP, PD; SF, H) \]

\(^4\) Generally population pressure affects land allocation, but the effect on managed and natural forests may differ. Population density may also, among other things, be related to the distance of forestry land to markets. In addition, both economic prosperity (GOP) and population density (PD) may affect forestland allocation through directly unobservable nontimber values of forests.
In Hainan, the institutional changes from socialist transformation to current economic reforms have been less endogenous with the socio-economic development, but greatly determined by political ideology. Therefore, they can be treated as exogenous variables (Besley 1995).

_Econometric specification_

The econometric specification for both managed forests and rainforests is based on equation (2). To avoid omitted variables bias, due to unobserved county-specific institutional and environmental factors, a panel data analysis with individual constant terms for counties, was used. Fixed-effect panel data estimation is appropriate when cross-section units are not sampled from a large population, and the differences between units can be viewed as parametric shifts of the regression function (Greene 1997, p. 623). This clearly is the case in the present study, because our sample includes all the counties in Hainan. Therefore, the estimated parameters cannot be used to predict behavior outside the present sample, although our method should be applicable in other studies of land allocation.

As macroeconomic, as well as geographic and socio-economic factors, are likely to affect land allocation in different counties in Hainan, we allow contemporaneous correlation of cross-section units (Greene 1997, p. 658, Hsiao 1986). Lagged values of exogenous variables did not improve the statistical performance of the two estimated equations. Therefore, to take into account the relatively strong autocorrelation in the data, the Cochrane-Orcutt transformation is used and the model estimated using the iterative Generalized Least Squares method (Kmenta 1986 pp. 622-625, Greene 1997, pp. 651-669). The econometric specification is

\[
\text{FC}_{it} = \alpha_i + \sum_{j=2}^{13} \beta_j \text{D}_j + \beta_2 \text{GOP}_{it} + \sum_{n=1}^{3} \beta_{(2+n)} \text{P}^n_{it} + \beta_6 \text{SF}_{it} + \beta_7 \text{H}_{it} + \beta_8 \text{DU}_{it} + \beta_9 \text{H}_{it} \text{DU}_{it} + \epsilon_{it},
\]

where subscripts i and t indicate the counties and years, respectively; D are the regional dummy variables; FC denotes the forest cover (%); PD is population density (in persons per ha), and GOP is deflated per capita output value (Yuan per capita); \text{P}^n (n=1,2,3) are the real
price indexes of agricultural products, tropical crops and timber, respectively, i.e., they are divided by the price index for rural industrial materials, following Yin and Newman (1997); SF denotes the ratio of land owned by state forestry firms to total forestry land and H is the ratio of the household responsibility forestry land to total forestry land. All variables except SF and H are in natural logarithms.

Hainan has a total of 19 counties and one state reclamation bureau. Due to frequent changes occurred in the administrative system, we combine the neighboring counties of Haikou City and Qiangshan County; Tongza, Qingzhong and Baotin; Chenmai and Linguo; and Baisa and Changjiang. This ensures that the 13 cross-section units thus obtained remain the same throughout the examined period. Since data on the state reclamation bureau are very spare, the bureau is excluded from this study.

The period we examined covers the years from 1957 to 1994. The years 1980 to 1987 were characterized by uncertainty concerning the direction of economic reforms, which were in an experimental phase. Farmers and local, even provincial, government officials did not know whether and how the reforms would be carried through. Forests suffered greatly from this uncertainty across the country. Therefore, a dummy variable, DU, is used to allow both the intercept, and the slope of the de-collectivization (H) to differ from the rest of the period studied.

To examine the difference between managed (mainly plantations) and natural forests (mainly rainforests), a behavioral model is estimated for both categories. Hardwood price is used as

5 We separate agricultural products and tropical crops since they have different price trends, and require different land qualities and compete with forestry in different way. We expect tropical crops are between forestry and agriculture in land quality requirement.

6 This specification provided the best statistical performance. Together with the logarithmic transformation the specification implies that the impacts of output prices and composite input price are assumed to be equal in absolute terms but to differ in sign.

7 The aggregation of natural and managed forestland may be appropriate for regions dominated by either natural forest or plantation forest. In the case of Hainan Island, natural forest and plantation forests each account for half of total forests. Aggregation necessarily loses information, therefore, separate regressions are necessary.
the timber price for the rainforest; the timber price for plantation forest equation is the price of timber produced from plantation, mainly Eucalyptus. Although the same economic principles apply to managed and rainforests, the development of managed and rainforest areas may respond differently to relative prices and the institutional variables because investment in plantation forestry resembles investment in other sectors, such as agriculture, while harvesting of natural forests is a mining-like activity. We expect rising forest prices lead more economically inaccessible natural forest accessible, reducing the natural forests, while increasing timber price become incentive for forest management, increasing the managed forest.

In the case of rainforest, only 8 of the 13 cross-section units were of significant size during the period studied. The harvesting of rainforest has been regulated: it is either that only a selective cut has been allowed since the late 1970s or harvesting has been prohibited altogether since the mid-1980s (in other words they have become "managed forest"). Therefore, we exclude the 5 cross-section units where rainforests make up less than 2% of the total area of the county (in the late 1970s) and the period after 1985 in the regression model explaining the area of rainforests. The total number of observations is 72 (8 units for 9 points in time). The estimated function includes the same explanatory variables as equation (3).

Estimated results and analysis

As expected, higher timber prices promote forestry investment in managed forest as measured by plantation forest cover. However, the rainforest land area decreases as timber price increases, implying that the increasing hardwood price has, at least in the past, increased mining-type harvesting of rainforests. The agricultural product price has a positive impact on both managed and natural forest cover. This runs counter to the theoretical hypothesis, and suggests that rising agricultural product prices do not lead to encroachment on forestland in

8 Because the estimation periods differed, seemingly unrelated regression (SUR) –method could not be used to estimate the managed and rainforest equations together and to improve the efficiency of the estimates. No significant contemporaneous correlation between the error terms from the equations for rainforest and managed forests was found when the same sample length was used.
Hainan. In a developing subsistence economy, this result may be due to the fact that farmers can meet their income needs with less harvest income when agricultural prices increase. Also there does not seem to be any serious conflict between agriculture and forestry. In some cases, they are complementary since forest management is not only for timber. A significant part of plantation forest is for protection for agriculture land purpose. Therefore increasing agricultural prices encourage the investment in this kind of forest management, like agricultural infrastructure.

Table 2. GLS estimation results for managed and rainforest cover in Hainan, 1957-1994*
(The t-values are in parentheses below these estimates)

<table>
<thead>
<tr>
<th>Variable description</th>
<th>Managed forest cover (%)</th>
<th>Rainforest cover (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_1$</td>
<td>Constant**</td>
<td></td>
</tr>
<tr>
<td>Pa</td>
<td>Agricultural products price</td>
<td>0.11 (1.16)</td>
</tr>
<tr>
<td>Pc</td>
<td>Tropical crop Product price</td>
<td>-0.40 (4.22)</td>
</tr>
<tr>
<td>Pt</td>
<td>Timber price</td>
<td>0.61 (5.81)</td>
</tr>
<tr>
<td>PD</td>
<td>Population density</td>
<td>2.21 (42.57)</td>
</tr>
<tr>
<td>GOP</td>
<td>Per capita gross output value</td>
<td>0.59 (22.48)</td>
</tr>
<tr>
<td>SF</td>
<td>Percentage of SF land to total (%)</td>
<td>0.42 (7.17)</td>
</tr>
<tr>
<td>H</td>
<td>Ratio of HRS to total (%)</td>
<td>0.79 (8.56)</td>
</tr>
<tr>
<td>DU</td>
<td>Dummy for uncertainty</td>
<td>-0.09 (2.73)</td>
</tr>
<tr>
<td>H•DU</td>
<td>Joint effect of HRS and uncertainty</td>
<td>-1.55 (15.49)</td>
</tr>
<tr>
<td>$\rho$***</td>
<td>Autocorrelation coeff.</td>
<td>0.64 (15.49)</td>
</tr>
<tr>
<td>Log-L</td>
<td>Log-likelihood</td>
<td>134.7</td>
</tr>
</tbody>
</table>

Notes:
* Data for managed forests is from 1957 to 1994 across 13 units; data for rainforest is from 1957 to 1985 across 8 units.

**The regional dummy variables are excluded in the Table.

*** A single autocorrelation coefficient is adopted because we found that different autocorrelation coefficients did not change the estimated results or standard errors markedly.

Plantation forests respond negatively to the tropical crop product price, implying that tropical crops compete for land with plantation. However, the rainforest and tropical crops may even
be complementary as indicated by the positive coefficient of tropical crop price in the rainforest equation. As noted above, tropical crops were mainly conducted by the state reclamation bureau, which certainly has transferred a significant rainforest to tropical crops. Like many other studies, our estimated results indicate that population has a negative effect on rainforest coverage. This suggests that growing population generally causes some rainforest to be converted into agricultural, industrial and residential land, and probably into wasteland after logging. However, the managed forest area in Hainan has increased with population. Thus, rising population has speeded up the exploitation of natural forest, but may have promoted plantation in Hainan.

The effect of economic development (or welfare), measured by per capita output value, also has a positive effect on managed forest cover. One explanation for this may be that economic development reduces e.g., transportation costs and costs of protecting property rights as infrastructure and law implementation are improved. The economic development may also have demand side effects. Strengthening demand for timber is reflected in timber prices. However, a wealthier society may also appreciate the in situ benefits of forests causing a positive correlation between plantation forest and GOP. For example in Hainan, about 20% of plantation forest is intended for environmental purposes. The positive effect of GOP on managed forests does not contradict the negative sign of GOP in the rainforest equation. Natural forests are examined over the period 1957-1985. Since then harvesting in rainforest has been fully regulated, indicating increased environmental concerns and a change in preferences towards protection of natural forests. The expansion of managed forest accelerated in the 1990s in line with the economic growth.

The share of forestry land controlled by state-owned enterprises seems to have a positive effect on plantation forest cover, but the effect is significantly negative for rainforest before 1985. This can be explained by the fact that state-owned forestry bureaus (or farms) were set up for two purposes: to afforest public wasteland and to exploit public natural forest. Our results also show that de-collectivization (H) promoted the loss of natural forest in the early part of the explored period (the negative sign of H in the second column of Table 2.), but may have worked the other direction in the 1980s (the positive sign of H*DU in the second column of Table 2).
Conclusions and Final Remarks

This case study shows that it is necessary and important to separate the natural forest and managed forest in analysis of forest change. It helps us to see how the mechanism of forest transition. At the beginning, the economic development and population growth promote the exploitation of natural forests. But when the natural forest decline, investment in forest plantation and management will be induced. When the natural forest continues to decline to some level and economy develops the value of remained natural forests will be reflected in environmental services and worth to be fully protected. Along this path, the economic development is important since the growth of economy not only increases the relative scarcity of forest products, especially the environmental value, but also supports the institutional improvement that is important for forestry.

The case of Hainan well represents the rest of China. The potentially forestable land area, which was as large as the forested land in Hainan two decades ago, has been gradually replaced by the managed forest with the economic growth, wood-chip export and institutional changes. Currently, the rest of China is very like Hainan two decades ago. The significant share of unforested land is neither due to the agricultural occupation or intended other land uses, but likely due to low timber prices resulted from weak demand from the economy and less well-defined land tenure or insecure property rights. Much land does not lack a defined owner, but the owner is unable or unwilling to enforce property rights making these areas in effect open access, and inactive management as a rational choice.

Therefore, the biggest challenge in China's forestry is not population and economic growth and the poor and limited land, but weak demand site and institutions that make forest management costly. The institutions, which are important in reducing transaction costs, may be even more important than the price incentives for its transition of non-active management into active management. Therefore, the priority in policy planning is to emphasize the development of institutions in order to significantly reduce property right protection costs for forest management and to provide more security and confidence for farmers concerning the continuity of the property rights.
Currently, it seems that governmental efforts are still focusing on direct investment through launching massive forestation programs. This may not be the most effective approach. Without the institutions that create cheap exclusion costs, closed access is unfeasible. Without closed access, any investment in silviculture is likely to be wasted. If forest management is profitable, private investment will be induced. The priority of government should be to invest in institution building that would promote the definition, transference and protection of property rights

References


