Forests **2014**, *5*, 214-233; doi:10.3390/f5020214

OPEN ACCESS

forests

ISSN 1999-4907

www.mdpi.com/journal/forests

Article

Local Dynamics Driving Forest Transition: Insights from Upland Villages in Southwest China

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Received: 31 October 2013; in revised form: 13 December 2013 / Accepted: 16 January 2014 / Published: 23 January 2014

Abstract: China has experienced extensive forest transition, from net deforestation to net forestation. Existing theories have highlighted economic growth, the intensification of agriculture and forest scarcity as the pathways of this transition, and studies, in particular from China, have also highlighted the contribution of a huge state afforestation program and the improved implementation and enforcement of forest protection policy and law. However, few studies have paid attention to local dynamics to provide a contextualized understanding of how forest transition has taken place at the local level and the significance of local factors in this change. This paper examines forest transition pathways in two villages in China. We consider the historical perspective and compare their local dynamics and variations to reach an understanding of the process of forest recovery at the local level. The results show that state forestry policies, including afforestation policy and tenure reform, arguably contribute to forest increase, while local processes including livelihood change and institutional factors play a key role in driving and shaping forest transition. We argue that there is a need for local-level studies and recommend including local institutions in forest transition analysis, contextualizing the socio-ecological interactions within the broader concept of political economy.

Keywords: forest transition; land use and cover change; afforestation policy; local institutions; China

1. Introduction

Forest transition is widely understood as a process of forest cover following a U-shaped curve (Kuznets curve) from net deforestation to net forestation, aligned with countries undergoing a course of modernization and development. Derived from historical studies of forest, forest transition theory holds that forest stocks change in predictable ways as societies undergo economic development, industrialization and urbanization [1–4]. Empirically, forest transition theory is clearly illustrated in several developed countries such as Denmark, Portugal and the US [4–6], and there is growing recognition of forest recovery in developing countries including China, India and Vietnam [7–11].

Scholars are interested in forest transition analysis as a means of understanding the driving forces behind forest recovery and land use change. Extensive studies on the pathways of forest transition have concluded that modernization and development are the principal drivers behind increased agricultural productivity. Subsequently, off-farm job opportunities that pull farmers off the land, results in the abandonment of large areas of marginal agricultural land for forest regeneration [9,12,13]. Studies that identified a pathway from forest scarcity to afforestation have also concluded a scarcity of forest products and declining ecosystem services have prompted government and land mangers to increase afforestation investment [9]. Recent case studies also identified a broader range of processes associated with forest transition, including: (1) contribution of *state forest policy* in improving forest legislation and increasing afforestation investment [11]; (2) *globalization* promoting integration of national economics and international conservation ideologies [13,14]; and (3) *smallholder agricultural intensification* leading to concentrations of cultivated area and a gradual reforestation of hillsides [10]. However, most studies remain at a large geographical scale; few researchers take a grounded approach to their analysis that is contextualized from the local up to the national or global scale [15], and understanding of the local factors affecting forest transition is therefore limited. Moreover, there is a growing body of literature questioning the relations between forest transition and modernization theory. This work recognizes and discusses the contingency of forest dynamics in context specificity [16–18], calling for further research to provide valuable insights into the heterogeneity and complexity underlying forest cover change and its interaction with political economic dynamics.

China's forest has undergone a huge transition in the last two decades [9,11,19], alongside with the introduction of a series of agricultural reforms. This turning point in forest transition in this country occurred in the 1980s, and has been sustained ever since [11]. FAO (Food and Agriculture Organization of the United Nations) reports an increase of total forest cover in China from 21.2%–28.7% between 1990 and 2005 [20]. Previous studies claim that, apart from economic growth and urbanization, a significant contribution to this impressive forest recovery has been made through improved implementation and enforcement of forest policy and laws, and vast investment in afforestation [11,21,22]. Some studies question the environmental outcome of forest transition, pointing to the increase in monoculture plantations [16,23–25], and reduced contribution to biomass and carbon stock, as forest volume per ha continuously decreases [8,26]. However, there are very few studies that have documented local dynamics, and how human agency has been driving and shaping this change in China [27,28]. In particular, a historical perspective of the environmental and socio-economic change involved would provide a critical understanding of forest recovery in the context of broader institutional changes and policy, which are neglected in many studies.

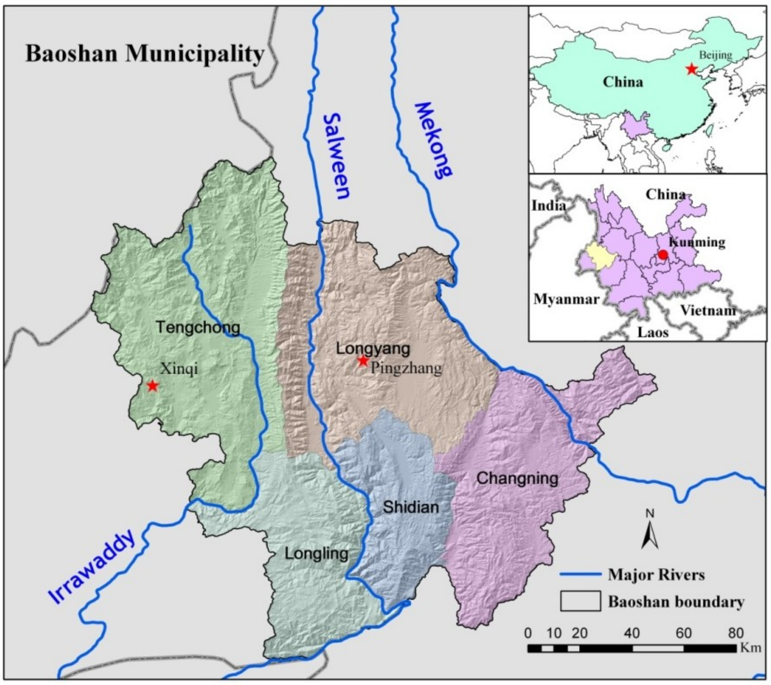
Building on existing theories about forest transition pathways, this research provides new insights into how local dynamics matter in driving and shaping forest transition. By reexamining China's contribution to forest transition through improvement of its legal framework and state afforestation policy, this article also contributes to the growing number of studies focusing on local processes in land use change in the highlands of mainland Southeast Asia [29–32]. Focusing on two villages in upland Yunnan in Southwest China, our study examines their local paths of forest transition in the context of institutional change and local livelihood dynamics. The research shows state forestry policies, including afforestation policy and tenure reform, make limited contribution to increases in forest, while local processes including livelihood change and institutional factors play a key role in driving and shaping forest transition. As suggested by the model put forward by Overmars *et al.* [33], we argue the land use and cover change is a result of interacting driving forces and actors, and support the need for local-level studies to include local institutions in forest transition analysis, contextualizing the socio-ecological interactions in the broader system of political economy.

The paper is organized into six major sections. The next section provides an overview of the research site, including the biophysical and socio-cultural characteristics of the two villages, which is followed by a description of the research methods. The results section presents the history of the study villages with a focus on key historical events in the villages and local dynamics in response to macro-institutional changes, followed by land use and land cover change analysis and local livelihood dynamics in 1989, 2002 and 2010. Drawing on empirical findings, the discussion provides a contextualized understanding of forest transition in the two villages and the implications for forest transition analysis. The paper concludes by offering up recommendations for further forest transition research.

2. Research Sites

This research was conducted in two selected villages in the Baoshan municipality of Yunnan province (see Figure 1). Both villages are located in a typical subtropical zone at an elevation of 1530–2640 m ASL, with 1000–1500 mm of rainfall and an annual temperature of about 14–17 °C. Communities in these areas settled more than 300 years ago and used to practice upland agriculture, growing corn, buckwheat, barley and rice, mainly for subsistence. However, their farming systems are now more integrated into the market economy, and trees such as walnut, chestnut, pear and camellia are being planted for their agroforestry functions and upland economic development. A large area of forest is managed partly collectively and partly individually, with the dominant forest cover plantation. Both villages have been involved in various state afforestation programs including the largest program, Sloping Land Conversion Program (SLCP), to transition marginal cropland to forest [34].

Figure 1. The location of the study sites.



Located on the margins of China, Baoshan is classified as one of China's most underdeveloped regions, and the study villages, particularly Pingzhang, were poor villages below the poverty line, typical within this municipality. The steep mountains and geophysical conditions limit farmers' access to technology, market opportunities, central funding support and other resources that could improve their livelihoods [35]. Current market integration and forest policy reforms have dramatically changed local landscapes and livelihoods. Table 1 shows the biophysical characteristics and socio-cultural features of the two villages in Baoshan municipality.

3. Research Methods

Qualitative and quantitative data was collected from three primary sources from August 2010 and December 2011. First data was collected relating to land use practices, the implementation of state policy, and other local factors with the potential to influence land use. This was obtained through: (1) semi-structured interviews eliciting key information from elders, village leaders and local government officials (totally n = 32); (2) a questionnaire survey of a randomly-chosen set of 103 households (43 in Pingzhang village and 60 in Xinqi village, respectively); and (3) three focus group discussions in each village (5–6 villagers in each focus group discussion). Data on land use practice was collected to obtain in-depth understanding of local historical perceptions of land use change, institutional arrangement of forest management and implementation processes of different forest policies.

Table 1. Biophysical characteristics and socio-cultural features of the two study villages.

Study site	Pingzhang Village, Longyang County	Xinqi Village, Tengchong County
Geography		
Area (km^2)	14.79	53.19
Elevation (m ASL)	1535–2597	1692–2546
Annual rainfall (mm)	1037.3	1428.5
Longitude/latitude	E99.01°–99.05°; N25.14°–25.20°	E98.26°–98.33°, N25.03°–25.11°
Socio-economics		
Subunits	5 natural villages	5 natural villages
Ethnicity	Yi and Bai	Han-Chinese
Total households (2010)	410	1026
Total population (2010)	1680	4276
Net income per capita	360 USD (2010)	561 USD (2010)
Livelihood strategy	Farming, animal husbandry and forestry, an increasing amount of off-farm work	Forestry, farming, off-farm work
Ecology and land use		
Dominant forest vegetation	Pine (*Pinus armandii*, *Pinus yunnanensis*), alder (*Alunus nepalensis*).	Fir (*Taiwania flousiana*, *Tsuga dumosa*), pine (*Pinus armandii*, *Pinus yunnanensis*), alder (*Alnus nepalensis*),
Tree plantation	Walnut (*Juglans sigillata*), alder (*Alnus nepalensis*), pear (*Pyrus pyrifolia*)	Walnut (*Juglans sigillata*), fir (*Taiwania flousiana*), alder (*Alnus spp.*) Camelia (*Camellia reticulata*)
Cultivated farmland	Rice, corn, wheat and barley	Rice, corn
Related forest policy implementation	Since 2003, Sloping Land Conversion Program	Since 2003, Sloping Land Conversion Program, 2009 Camellia plantation

Second, spatial datasets were developed from Landsat and RapidEye images, topographic maps and ground truth points (Table 2). To interpret the images and validate the classification results, ground points were collected at both sites, using GPS (Geographical Positioning System). The selection of the years 1989, 2002 and 2010 aims to understand land use and institutional change when the forest was allocated to individual households (at the time of market liberalization in the 1980s) and the start of SLCP in 2002. The land-use image for 2010/2011 helps to explain the consequential change from institutional dynamics and the longer-term impacts of SLCP.

Table 2. Specification of spatial data used for analysis.

Region **Study sites**	**Longyang County** **Pingzhang Village**	**Tengchong County** **Xinqi Village**
First set	26 February 1989, Landsat TM 30 m	26 February 1989, Landsat TM 30 m
Second set	13 January 2002, Landsat ETM^{+} 30 m	13 January 2002, Landsat ETM^{+} 30 m
Third set	24 December 2010, RapidEye 5 m	30 December 2010 4 January 2011, RapidEye 5 m
Scale of topographic map	1:50,000	1:50,000

To generate comparable land use/cover data across sites and time, radiometric corrections were applied before classification. SLCP targeted areas were overlapped on the land use map to understand the contribution of the policy. Satellite images were classified using Definiens (an object-based classifier), following the definition of natural vegetation and classification concepts defined in Land Cover Classification System [36]. Forest cover was calculated by summing up open canopy and closed canopy forest. Image objects at different levels were firstly created by segmentation according to size and shape criteria, and then we derived classes using the hierarchy approach. Broad classes such as vegetated, non-vegetated and waterbody objects were classified on the highest image object level with coarse resolution, detailed classes were further defined on the lower object level with fine resolution. Rule sets, sequence of procedures for classification and differentiation of classes were developed for Landsat and RapidEye images separately. Furthermore, we manually corrected misclassified objects to improve the classification results. We assessed the accuracy of classification using randomly generated points, where reference class value was given according to visual interpretation of original images. An accuracy assessment of classifications showed the overall accuracy was above 85% (see supplementary materials Table S1 and S2 for details of confusion matrix). Deriving and assessing accurate and detailed land use classification results, with limited reference information for the past decades, is still a challenge. We classified the past Landsat images with good accuracy, comparing results with higher resolution RapidEye images. Assessing the accuracy by visual interpretation of points on the original images might introduce more uncertainty in assigning reference class value for coarse resolution images. We recommend using any available ancillary reference data to assess the accuracy of the classification from coarse resolution images to reduce this uncertainty.

Lastly, we collected government statistics on socio-economic data related to demographic change and incomes to complement the remote sensing data. Official documents and policy papers including several key forestry and agricultural policies were widely investigated at different levels. Materials and documents from central, provincial and township levels gave us a sound understanding of the political and socio-economic context. It also provided useful insights on the associated institutional and policy changes related to forest transitions.

4. Results

4.1. History of Forest Use in Pingzhang and Xinqi Villages

In China, the history of institutional change, with regards to agricultural production and forest management, can be simply characterized as a process of transformation from collectivization, in the Mao era (1949–1978), to Post-Mao era de-collectivization (after 1978). That said, the local history and processes in response to macro changes are more complex. Table 3 outlines the history of land use change and local institutional dynamics of the two studied villages, in the broader context of political and socio-economic changes.

The two highland villages have a long history of forest management, along side shifting cultivations of buckwheat and corn. Before the establishment of the People's Republic of China in 1949, Yi people in Pingzhang practiced their customary rights and sacred forest management, whilst Han people in Xinqi collectively managed their forest. However, during the period of The Great Leap Forward in 1958 and the Cultural Revolution from 1966–1976, massive deforestation occurred in both villages, as the commune system of collectivization was introduced. Significant amounts of timber were harvested to support industrialization, including huge areas of forest to fuel backyard steel smelters and build communal mess halls, as observed in other parts of China [37,38]. The commune agricultural system also resulted a low productivity, and as a consequence, local people had to cut trees for agriculture production in the 1960s. In addition, resettlement programs in Pingzhang, resulted in the immigration of Bai people about 50 years ago. As the immigrant ethnic group started collecting firewood in what the Yi people believed to be sacred forest, Yi ritual practices were disrupted, creating tension between the two ethnic groups. On the other hand, in Xinqi, people started to invest in afforestation by setting up their first collective forest farm for collective forest management. Village elders were able to recall those events in interviews we conducted as part of this study:

> *"……Great Leap Forward campaigns brought about the loss of more than two thirds of our local forest [in Pingzhang], but later, we have more deforestation, as our land was reallocated to the Bai people, who not only cut the forest for agriculture, but also use the wood from our scared forest…."* [20 September 2011, in Pingzhang].

> *"People [in Xinqi] suffered a lot from serious deforestation… several landslides eroded our paddy field during Great Leap Forward and Cultural Revolution…. So, in 1962, we established our first collective forest farm and planted 167 ha of fir trees that aimed to protect our paddies…."* [13 April 2011, in Xinqi].

Table 3. Timeline of local institution and land use narratives in Pingzhang and Xinqi.

Period of Time	**Socio-Political Context**	**Pingzhang**		**Xinqi**	
		Institutional Structure	**Land Use Narratives**	**Institutional Structure**	**Land Use Narratives**
Before 1949	- World War II - Civil War	- Yi people customary rights on land and forests	- Shifting cultivation for growing buckwheat - Practice sacred forest by Yi	- Han-Chinese collectively managed forest	- Deforestation due to war - Shifting cultivation for growing buckwheat and corn
Early 50s to late 70s	- Collectivization - Great Leap Forward - Cultural Revolution.	- Establishment of commune system - Bai people resettlement project intervened customary sacred forest	- Massive deforestation during 1958 for industrialization - Clean forest for Bai people resettlement project in the 60s - Clean forest for food security - Introduced terracing technique for rice and corn in the 60s - eroded sacred forest practice in 70s	- Established first collective forest farm in 1962 for afforestation - Collective forest management under commune system	- Serious deforestation during the 50s - Invested in afforestation in the 60s for protecting paddy fields with 167 ha plantation of fir
Late 70s to late 80s	- Reform and opening market policy - De-collectivization - Household responsibility System - Forest Tenure reform	- Decline of commune system - Increased private ownership in agricultural land - Communal use forest management - Unclear private and collective forest rights - Decline of customary sacred forest	- Clean forest for agricultural expansion of corn and buckwheat cultivation - Overharvest of forest due to unclear ownership - Incomplete forest allocation - Collective forest for communal use	- Expended to four collective forest farms - Increased private ownership of agricultural land - Forest redistribution from commune to individual households	- Deforestation and conflict after forest redistribution in private forest - Invested in afforestation in barren land with 400 ha plantation
Late 80s to early 90s	- State afforestation program - logging quota	- Administrated in line of township government	- Plant tree on marginal land with free seedling from government - Aerial seeding on barren hills - Limits of species (pine)	- Forest re-collectivization in the village in 1985 - Expended to 17 collective forest farms	- Collective forest farms expended to 1667 ha - Collective forest management
Late 90s to present	- Sloping Land Conversion Program (Grain for Green, SLCP)	- Introduction of Organic law for direct election of village committee in 2002 - Eliminate the role of party secretary in village committees in 2007	- Top-down approach in SLCP - Exotic species (pear) with survival rate lower than 50% in SLCP - Over 300 households involved with 77.95 ha plantation in SLCP - ICRAF introduce participatory agroforestry in 2002	- Establish sharing holding system for forest redistribution in 1997 - Introduction of Organic law for direct election of village committee in 2000	- Participated SLCP, in 2002, 2003 and 2005 - Participated walnut plantation in 2009 and camellia plantation in 2010 - Increased village revenue from timber harvest in collective forest farm

In the early 1980s, after the collapse of Mao's commune system, the government carried out de-collectivization reform to combat food shortages. Both villages started to reallocate collective agricultural land to individual households using the Household Responsibility System. This aimed to provide farmers with incentives and, following this shift in agricultural policy, the same measures were adopted by the forest sector for forest redistribution. This policy also allowed farmers to claim user rights to forestland, and convert large areas of land for agricultural production. As observed in other part of China [39,40], the impact of de-collectivization of agriculture in these villages were mostly positive as farmers now had incentives to produce crops, leading to a dramatic increase of food production and rural development. On the other hand, the success of forest implementation was limited [41,42]. In Pingzhang, due to unclear ownership and tenure duration, forest redistribution led to the unexpected overharvesting of forest. As a result, only a third of forest was redistributed, as most villagers wanted to keep the collective forest for communal use. In Xinqi, farmers immediately cut the trees for cash after the forest redistribution, resulting in the villagers reaching a common agreement to return private forest to collective ownership and management in 1985. Most interviewees from both villages expressed that short tenure periods and unclear property rights encouraged shortsighted management of forest. As a consequence, people who worked their land irresponsibly, exploiting it for short-term gain, gained more than those who worked it responsibly. With the launching of the restricted quota system for logging, government efforts at forest redistribution ceased, leaving the first forest tenure reform of the 1980s incomplete.

During the later 80s and mid-90s, Baoshan Forestry Department began implementing afforestation programs across the municipality, in response to the rapid deforestation of the past two decades. The farmers of Pingzhang received free seedlings and were encouraged to plant trees on low-yield, high-elevation agricultural land. The forestry department also used aerial seeding for low-cost, rapid afforestation of barren hills, planting exclusively pine species. In Xinqi, the villagers continued their own initiatives by expanding the collective forest farms area to 1667 ha. In fact, since the end of the 1990s, 17 collective forest farms have been established. Xinqi also formed a democratically elected committee that governs the collective forest farm, acting independently from official village administration. The afforestation program led by the forest department in Pingzhang and self-organized forest plantation in Xinqi has resulted in different outcomes, as expressed by the village head of each village during our interviews:

> *"The survival rate of the pine is not so good; people [in Pingzhang] just do not care much about pine; Bai people still rely on livestock in the young plantation area, as they are lacking agriculture land*" [23 September 2011, in Pingzhang].

> *"We [in Xinqi] have benefitted a lot from collective forest farm in both terms of forest health and profits. Over the years, our forest grows very well and we have logged many timbers for selling and use the forest profits for infrastructure and social development including a school, a health clinic, elders' centers, roads and social insurance for all villagers."* [15 April 2011, in Xinqi].

Moreover, in Xinqi efforts towards afforestation and forest protection greatly improved forest quality and economic value. By setting up the share system, the administrative village began to redistribute the forest again in 1997. The allocated forest was delineated and given to the collective forest farms, which took away responsibility for its management and harvest. As a result, the distribution of benefits from the harvest was discussed and agreed among the villagers, either for public goods or for individuals. However, the forest management in Pingzhang remains unclear with regards to property rights between private and collective forest, tension between the two ethnic groups and farmers' disincentive to invest in forest management and development.

Since 2002, the largest afforestation activities took place under SLCP in both villages. In Pingzhang, the program involved more than 300 households in the planting of 39.83 ha and 38.12 ha of forest in 2003 and 2006, respectively. However, the SLCP was implemented as a top-down approach, with the land zoning and tree species selection exclusively decided in the township, without consulting local farmers. Many farmers complained that as an exotic species, the pear tree was unsuited to local conditions. The survival rate of pear was less than 50% according to a survey conducted by the township forest stations. Thereafter, the World Agroforestry Centre (ICRAF) introduced a program for poverty reduction and forest conservation in Pingzhang to provide support to complement the state's SLCP, including training in walnut plantation and management, agroforestry development for the SLCP and other capacity-building activities. In Xinqi, on the other hand, the village's successful forest management and conservation activities have attracted government investment in the forest, including SLCP implementation in 2002, 2003 and 2005, a provincial program of walnut plantations in 2009, and a county program of camellia plantation in 2010. The village committee and local government implemented these programs after an extensive consultative process.

To summarize, Pingzhang and Xinqi have undergone dramatic changes due to the impact of various forest policies and economic development. Xinqi has exhibited stronger local institutional strength and self-organization in afforestation, forest conservation and forest distribution. Pingzhang's forest institutional governance, however, has been weak, and heavily influenced by upper level government. The differences between the local institutions in these two villages, and their forest governance, have led to local variations in environmental outcomes, as examined in the following section.

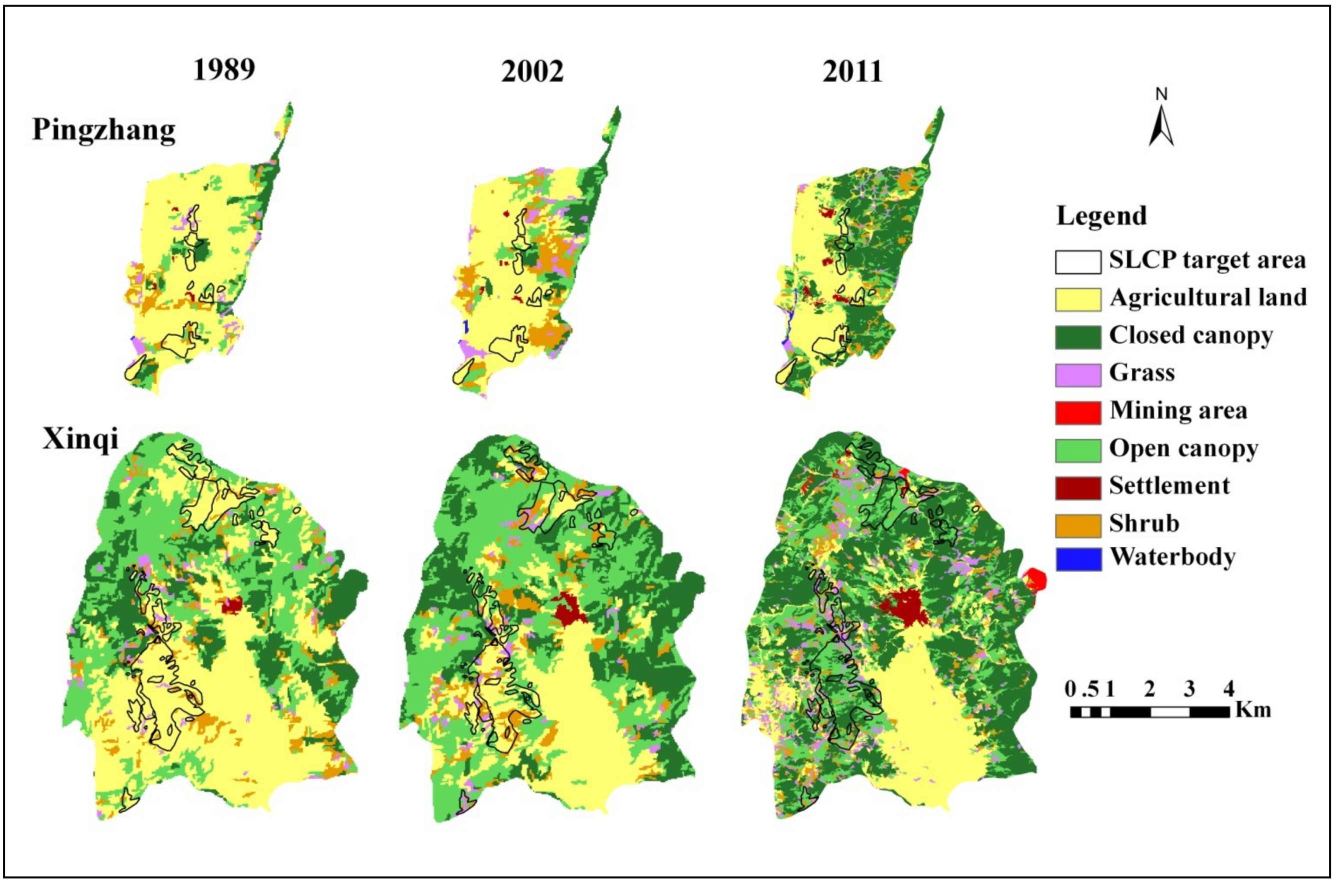
4.2. Land Use and Cover Changes in the Case-Study Villages since the 1980s

Table 4 and Figure 2 shows land use changes and forest transition since the 1980s in both villages. In Pingzhang, forest coverage increased from 18.23% in 1989 to 22.26% in 2002 and 49.48% in 2011. However, a significant decline in agricultural land area began in 1989–2002, even before the introduction of the SLCP, reducing agricultural land to 221.4 ha. Most farmland was abandoned or converted to grow tea, accounting for an 8.63% increase during the period from 1989–2002. As a result, although agricultural land area decreased, the increase in forestland only accounted for 4.37%, with a small increase in closed canopy forest of 1.37%, and in open canopy forest of 3.07%. Since the SLCP, the conversion of a significant amount of agricultural land has continued, reducing agricultural land account to 252.05 ha. Abandoned agricultural land with shrubs and grass was delineated as part of the SLCP. The ICRAF afforestation program, beginning in 2003, mainly focused on providing high-quality seedlings for tree plantation on Pingzhang's barren land. Since 2002, the forested area has increased by 26.75%, with closed and open canopy forest making up 35.71% and 13.77% of the total area, respectively. However, the contribution from SLCP to this forest cover change accounts for 21.88 ha or 5.5% of total increased forest area.

Table 4. Land use and cover change in Pingzhang and Xinqi in 1989, 2002 and 2011.

Land use and cover change	**1989**		**2002**		**2011**		**1989–2002**		**2002–2011**	
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)
Pingzhang										
Closed canopy	133.11	9.00	153.36	10.37	528.25	35.71	20.25	1.37	**373.71**	**25.26**
Open canopy	136.44	9.23	181.89	12.30	203.66	13.77	45.45	3.07	22.09	1.49
Agricultural land	1053.81	71.27	832.41	56.30	580.55	39.25	**−221.40**	**−14.97**	**−252.05**	**−17.04**
Settlement	5.85	0.40	8.37	0.57	23.84	1.61	2.52	0.17	15.47	1.05
Shrub	93.6	6.33	221.22	14.96	102.93	6.96	127.62	8.63	−118.53	-8.01
Grass	55.17	3.73	78.39	5.30	33.16	2.24	23.22	1.57	−44.67	-3.02
Waterbody	0.54	0.04	2.88	0.19	6.86	0.46	2.34	0.16	3.98	0.27
Xinqi										
Closed canopy	925.11	17.39	1315.53	24.73	2147.37	40.37	390.42	7.34	**830.9**	**15.62**
Open canopy	1556.28	29.26	1986.75	37.35	1202.05	22.60	430.47	8.09	**782.1**	**14.70**
Agricultural land	2365.47	44.47	1438.83	27.05	1251.66	23.53	**926.64**	**17.42**	−188.34	−3.54
Settlement	15.03	0.28	39.96	0.75	69.88	1.31	24.93	0.47	29.92	0.56
Shrub	347.04	6.52	403.20	7.58	280.19	5.27	56.16	1.06	−122.95	−2.31
Grass	110.07	2.07	134.73	2.53	328.46	6.18	24.66	0.46	193.58	3.64
Mining area	0	0	0	0	39.48	0.74	0	0.00	38.99	0.73

Figure 2. Land use and change in Pingzhang and Xinqi in 1989, 2002 and 2011.



In Xinqi, there was an increase in forest coverage from 46.65%–62.08% of the total area in 1989–2002. It stabilized at 62.97% in 2011, with closed canopy forest making up 40.37% of the total area. Xinqi had the largest-scale agricultural conversion before the SLCP in 1989–2002, losing 926.64 ha of its agricultural land, accounting for 17.42% of total land area. Most of the agricultural land was converted to forest. There was a 15.43% increase in forest cover with 7.34% and 8.09% of closed and open canopy forest, respectively, from 1989–2002. After the SLCP, the reduction in farmland area only accounted for 188.34 ha, 3.54% of total land area. Forest structure has changed with an increase in closed canopy forest of 15.62% of total area. That said, total forest coverage was stable from 2002–2010. Figure 2 shows the contributions from SLCP to keeping the forest coverage in Xinqi was at a significant level. The forest structure has changed since 2002. Open canopy forest has decreased by 14.7%, because the newly planted open forest in the late 80s by collective forest farms has closed now.

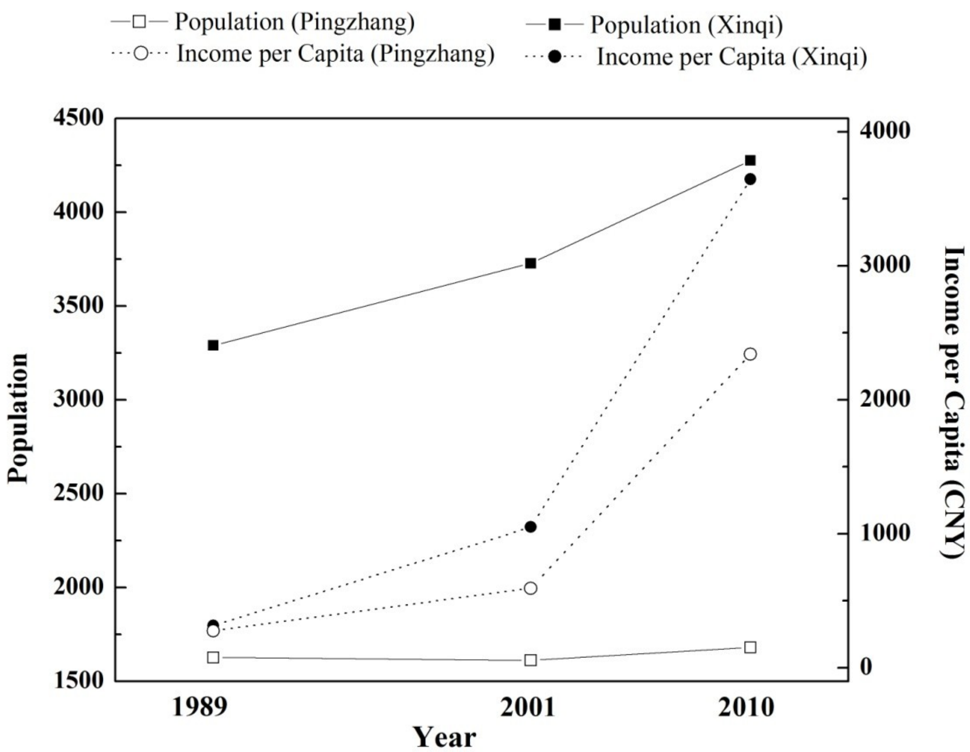
In sum, farmers started to abandon their agricultural land after 1989 when agriculture production was improved by widespread use of high-yield varieties and chemical fertilizers. The two villages adopted different approaches to their use of agriculture land. In Pingzhang, most people abandoned the land, although a few started tea plantations, while in Xinqi, inhabitants engaged in self-organized afforestation that contributed to a considerable increase in forest cover. This was when Xinqi initiated its own forest redistribution arrangement, encouraging farmers to plant trees. Afterwards, the SLCP gave both villages the opportunity to diversify their agricultural systems with further tree plantation, but the contribution from SLCP to additional forest increase was limited. The overall results show that

Xinqi has a greater forested area covering 62.39% of the total area, of which 40.37% is closed canopy, and large scale afforestation took place by collective forest farming during 1989–2002. On the other hand, Pingzhang has only 49.48% forest coverage, of which 35.71% is closed canopy. Between 2002 and 2011, Pingzhang increased its forest cover, while in Xinqi it is stagnating.

4.3. Livelihood and Population Dynamics after the 1980s

Livelihoods have undergone dramatic changes in Pingzhang and Xinqi since the 1980s. After considerable problems of low productivity and food insecurity under the commune system, the de-collectivization reform in the late 1970s provided a strong incentive for agricultural production, which increased rapidly in the 1980s [40,43]. Records from both villages show a dramatic increase in agricultural output and income since the 1980s (see Figure 3). More recently, there has been a clear move in local livelihoods from subsistence to market-oriented production.

Figure 3. Income and demographic changes in Pingzhang and Xinqi.



Note: The national poverty line was 350 CNY in 1989, 625 CNY in 2001 and 1274 CNY in 2010; 1 USD = 6.5 CNY in 2011.

Along with this tendency, the farming system in both villages changed to more intensive agriculture and forest management, with farmers making a wide range of efforts to invest more for better returns in agriculture and forestry. Several cash and tree crops have been introduced including tobacco, coffee, walnut and camellia, and walnut and other trees have replaced low-yielding buckwheat cultivation. While the SLCP has reduced the area previously used for corn cultivation, production has increased using new corn varieties and chemical fertilizers. In both villages, a large area of rain-fed paddy field has been converted to tree plantation or agroforestry as it lacked irrigation infrastructure and produced low yields. As reported by the heads of both villages, lately the farmers' "rice bowl" relies more on the external market than on subsistence farming. For instance, the village head in Pingzhang stated that 60% of the rice consumed by 80% of Pingzhang's households is now bought rather than grown, and the same is true of 80% of rice consumed in 90% of the households in Xinqi.

The change in livelihood dynamics and farming systems corresponds with China's overall economic growth, which has benefited local income generation. Figure 3 shows the 1000% income growth in Pingzhang and Xinqi from 1989–2010, which has brought both villages well above the national poverty line. The overall economic growth and reduced burden on farmers provides more opportunity for off-farm activities, which make up a significant part of local income generation. According to the village survey, 55.8% of the sampled households in Pingzhang and 51.7% in Xinqi include people working in off-farm jobs, either outside the agricultural season or all year round. On average, 1.21 people in Pingzhang and 1.58 people in Xinqi in the sampled households are engaged in off-farm work for an average of 7.19 and 9.15 months a year, respectively. Economic growth and increasing off-farm opportunities are driving farmers to change their on-farm livelihood strategies. They are opting to change their focus on short-term agriculture for a combination of practices, and are willing to combine forestry investment as a long-term livelihood strategy with short-term intensive agriculture, and keep livestock as a medium-term livelihood strategy.

This economic growth diversifies local energy use, making it possible to use biogas, electricity and new stoves in the uplands and reduces local dependence on fuel wood, which is now mostly used in winter for heating. As the village questionnaire survey shows, in comparison to the 5.32 m^3 used in Pingzhang and 6.73 m^3 in Xinqi five years ago, annual fuel wood consumption per capita has dropped to 0.574 m^3 and 0.592 m^3, respectively, making a considerable contribution to forest conservation. Cutting forest for fuel wood rarely occurs now, as wood from pruning and de-branching is sufficient to satisfy demand.

The population of Pingzhang has become stable in the last two decades in contrast to growth in Xinqi, where it has increased from 3289 in 1989 to 4276 in 2010 (see Figure 3). Although there is a one-child policy, enforcement of the policy is weak in upland areas, and ethnic groups and upland rural families are eligible to have more than one child. The stabilized population growth in Pingzhang is due to the migration of young adults to off-farm jobs. In contrast, there has been a remarkable amount of immigration in Xinqi due to increased investment opportunities in mining and timber processing, as shown in the village records. Although populations have grown, forest cover has continually increased in both villages.

5. Discussion: Contextualized Understandings of Forest Transition

The results from both villages concur with previous studies on forest transition and dramatic afforestation in China during the last three decades [7,9,11,19], whilst also supporting the general observation of forest transition pathways [1–4,9]. After the extensive deforestation of Mao's era, the turning point in forest transition occurred in the mid to late 1980s, with significant forest recovery beginning in the late 1990s. However, from our empirical case study, this research argues that forest dynamics cannot be simply understood from modernization theories related to agricultural intensification, technique development, increased off-farmer job and impacts from forest policy. Instead, we should try to better understand how the broad-scale policy and socio-economic changes interact with local contextual factors and livelihoods dynamics, to produce specific outcomes in each local place [16–18]. Placing different local factors in dynamic social and institutional settings helps generate a more contextualized understanding of land use dynamics.

Unlike previous literature [11,21,22], the results from this research also suggest that state forestry policy, including the afforestation program and tenure reform, have limited contribution to forest transition. As shown, both villages started to convert agricultural land before the introduction of SLCP's massive state afforestation program. In Pingzhang, the increased forest area is not due to the SLCP; it is on barren land abandoned several years ago. Also, top-down implementation of SLCP led to the poor performance and low survival rate of exotic species. In Xinqi, although tree plantation under the SLCP has been successful, the forest area has changed little as a result of the program, as the villages already had high forest coverage. The SLCP is therefore favorable to maintaining the forest area with the new plantation. Forest tenure reform allocating forestland to individual families also contributed little to forest expansion. Instead, it caused more ambiguity about forest ownership, as also suggested by other scholars [41,44,45]. In Xinqi, people have had to re-collectivize forest management in response to the massive deforestation that followed the allocation of forest. Farmers in Pingzhang opted not to allocate its forest to individuals but to retain its communal use. Although Chinese forest policy makes a contribution to forest transition, they are far from being the only factors driving local process.

This research provides new insight into forest transition and the key role of local institutions in shaping it, calling for greater attention to local factors in land use changes as suggested by Castella *et al*. [29], Clement and Amezaga [30] and Sikor [32]. The local actors often perceive environment and react to policy differently, producing nonlinear dynamics in forest cover changes [46]. We have shown that both villages have undergone a dramatic transformation under the broad umbrella of political economy change, but have responded differently. Pingzhang went through a process of land reallocation as the resettlement program brought a new group of people to the territory. This added complexity to local institutional forest arrangements. The breakdown of customary sacred forest practices and upwardly accountable leadership has weakened active and sound local institutions in forest transition. In Xinqi, which has historically used the forest as a key livelihood resource, the village has been self-organized and built local institutions for forest conservation and management. The separation between the elected head of the collective forest farm from the village administration leadership in the local forest governance structure has enabled the collective forest farm to successfully manage the local forest and to expand continuously, with increasing local benefit. The state afforestation program has provided an opportunity for local forestry development. Although a large amount of logging has taken place, Xinqi is maintaining high forest coverage of the total area and continuously increasing the forest area, both at faster rates than those of Pingzhang. In fact, the spatial data collected has clear evidence of comparative difference in forest cover and density.

Moreover, although both villages are involved in afforestation, the local dynamics of involvement in tree planting and forest conservation are complex. This research has found that the two villages went through different processes of land use change in the forest transition, although overall forest cover has increased in both. In Pingzhang is a process of local passive participation in the externally-driven tree-planting program and is largely dependent on external investment, while afforestation in Xinqi is driven by local initiatives along with the state program, making forest regeneration easier and creating denser forest than in Pingzhang. Thus, while both villages have moved from deforestation to net reforestation, the quality and timing of the forest transition in each being largely different. Local historical and socio-economic contexts and social relationships have shaped the forest transition in both the spatial and the temporal dimensions.

6. Conclusions

This research has taken a grounded approach, contextualized from the local scale up to a large scale in an analysis that confirms that forest transition has occurred in China. In relation to theory, it also confirms that the pathways of forest transition co-exist along with modernization and economic growth, leading to increased agricultural production and intensification, technological development and off-farm opportunities [9,10,12]. Those are also the driving forces behind the land use change. Beyond that, this research highlights that forest transition has been shaped by local dynamics and particularly by local institutions interacting with broad state policy and social-economic changes. State forestry policies do not automatically affect all places in an equal manner, but local institutions mediate the influence of those policies. Local actors have responded to the state program and transformed their landscape. The local variations in institutional arrangements, historical practice of forest management and livelihood strategies bring about different environmental outcomes, which have temporally and spatially shaped the forest transition. The land use and cover change is thus a result of interacting driving forces and actors as suggested by the model put forward by Overmars *et al*. [33]. In creating state policy, special attention to local context and dynamics is therefore required to facilitate and favor a forest transition that will lead to the optimal environmental outcome. This research highlights the need for contextualized analysis of the heterogeneity and complexity underlying forest cover changes and their interaction with political economic dynamics.

Acknowledgments

This research was financially benefited from different sources. The Ford Foundation in Beijing financed the fieldwork of this research. Jun He acknowledges financial support from the I-REDD+ project funded by the European Union (Project No. 265286) for his writing time. This research is also part of the CGIAR Research Program 6: Forests, Trees and Agroforestry. We acknowledge Thomas Sikor and Adrian Martin's comments on the early version, valuable insights from three anonymous reviewers, Sally Sutton's copyediting assistance and Sam Grainger's help in revision.

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Supplementary

Table S1. Confusion matrix of land use map of Xinqin village, 2010.

		Reference Data							User Accuracy (%)
		Close canopy	**Open canopy**	**Agricultural land**	**Settlement**	**Shrub**	**Grass**	**Mining area**	
Classified Data	Closed canopy	19	2	0	0	0	0	0	90.48
	Open canopy	2	12	0	0	2	0	0	75.00
	Agricultural land	0	0	17	0	0	0	0	100.00
	Settlement	0	0	0	8	0	0	0	100.00
	Shrub	0	0	0	0	12	1	0	92.31
	Grass	0	0	1	0	5	7	0	53.85
	Mining area	0	0	0	0	0	0	12	100.00
	Producer Accuracy (%)	90.48	85.71	94.44	100.00	63.16	87.50	100.00	Overall Accuracy: 87.00%

Overall Kappa: 0.8465, total number of points was 100.

Table S2. Confusion matrix of land use map of Pingzhang village, 2010.

		Reference Data							User Accuracy (%)
		Close canopy	**Open canopy**	**Agricultural land**	**Settlement**	**Shrub**	**Grass**	**Waterbody**	
Classified Data	Closed canopy	8	1	0	0	0	0	0	88.89
	Open canopy	2	6	0	0	1	0	0	66.67
	Agricultural land	0	0	8	0	0	0	0	100.00
	Settlement	0	0	0	6	0	0	0	100.00
	Shrub	0	0	0	0	5	1	0	83.33
	Grass	0	0	0	0	1	6	0	85.71
	Waterbody	0	0	0	0	0	0	5	100.00
	Producer Accuracy (%)	80.00	85.71	100.00	100.00	71.43	85.71	100.00	Overall accuracy: 88.00%

Overall Kappa: 0.8592, total number of points was 50.