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RESEARCH ARTICLE

# Reforestation, livelihoods and income equality: Lessons learned from China's Conversion of Cropland to Forest Program

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## Abstract

Despite global momentum in restoration activities, their socio-economic implications are little studied. Thus far, the limited evidence available tends to overlook equity and equality outcomes. In this work, we aimed at investigating fairness within the Chinese Conversion of Cropland to Forest Program (CCFP), given the relevance of local people's support for the long-term success of land restoration and for the inherent belief that equity should be pursued also by environmental policies. Additionally, we propose a methodology to investigate equity and equality, from a quantitative perspective. Our results suggested a shift in the overall households' economic structure, with the main changes being a decrease in farming activities (−44 pp) and a sharp increase in out-migration (+44 pp), with the most significant variation within the lowest income groups (−57 pp and + 75 pp, respectively). We also observed that both equality (the Gini coefficient decreased by 23%) and equity (higher income increase for low-income groups) improved, and the best enhancement happened in the regions where the CCFP has been implemented for a longer time. Moreover, data showed that the main driver of inequality was households' income deriving from remittances, both before and after the Program implementation (with concentration coefficient equal to 1.1 and 1.0, respectively) but its effect decreased over time suggesting an increase in out-migration opportunities for lower-income households. Finally, we found that the level of participation in the Program holds a quite strong explanatory power for both on-farm and off-farm income (explaining 19% and 18% of their respective variability).

**KEYWORDS**
environmental policy, equity, inequality, payments for environmental services, restoration, socio-economic impact

## 1 | INTRODUCTION

The main purpose of restoration activities is to recreate an ecosystem that has been degraded or destroyed either by direct (e.g., unsustainable logging, overgrazing, etc.) or indirect (e.g., extreme climate events triggered by climate change) human behaviour (SER, 2021). Restoration can be broadly defined as the practices that seek to transform degraded land into ecosystems which could gradually regain their full functions and resilience (Reed et al., 2016). Often, the purpose of restoration activities is not limited to gaining ecological benefits. It is believed that restoration can boost rural development by improving ecosystem services (e.g., water quality, pollination, microclimate improvement, etc.), creating a local restoration economy (e.g., more jobs, better land productivity, new economic activities), and improving social conditions (by designing inclusive projects and/or allowing to regain a spiritual connection with the nature) (Mansourian & Vallauri, 2014). However, regaining ecological functions is not trivial, as attempts at restoration could culminate in the establishment of monoculture plantations, the introduction of non-endemic species, leakages towards other areas of the country, or the undervaluation of low-carbon ecosystems (Coleman et al., 2021; Fleischman et al., 2020, 2021; Reed et al., 2016). Moreover, by changing the land use within a landscape, restoration can also have negative social impacts (Buckley & Crone, 2008). For instance, restoration policies that result in the expropriation of agricultural land in the name of a greater environmental good could lead to a reduction in household income, increase food insecurity, and decrease the probability of long-term success of the Program (Delang & Yuan, 2015). As land degradation is a consequence of human behaviour, the support from the local population is a key factor for the long-term success of restoration activities, sometimes even more important than other ecological components (Nerfa et al., 2021).

In the context of forest restoration, improvements in socio-economic conditions (e.g., increase in income, reduction of poverty, etc.) can be driven by activities such as the sale of new forest products (Adams et al., 2016), the intensification of agricultural production on non-converted land (Opoku-Boamah & Stato, 2010), and the shifting of labour from on-farm to off-farm activities, due to the decrease in land available for farming. The latter could also lead to a greater diversification of livelihoods (Bullock & King, 2011; Groom & Palmer, 2012; He & Sikor, 2015; Huang et al., 2012; Komarek et al., 2014; Wang & Maclaren, 2012). The availability or scarcity of local off-farm employment can influence the decision of household members to migrate; for this reason, migration is a widely studied impact of restoration (Treacy et al., 2018; Zhang, 2017).

Livelihood diversification strategies triggered by restoration can lead to both a shift from on-farm to off-farm work and a change in on-farm economic activities, resulting in different impacts on migration trends (Sendzimir et al., 2011). Outcomes related to income change and poverty as a result of land rehabilitation programmes are mixed and highly dependent on contextual factors such as opportunities for off-farm employment, land productivity (both the reforested and the remaining agricultural one), land tenure, and the markets for newly produced services (e.g., timber and non-timber forest products, and ecosystem services) (Clement & Amezaga, 2009; Groom & Palmer, 2012; Sandewall et al., 2015).

Within the landscape of socio-economic considerations that can be done related to restoration policies, equity and equality deserve to be discussed. The inclusion of fairness analysis within ecological policy has been emphasized also by the Society for Ecological Restoration (SER) and the International Union for Conservation of Nature (IUCN), which suggested the pursuit of equity and equality as a guiding principle for policy design (Dickson et al., 2021). Until now, just a few studies have analyzed equity and equality within restoration projects, with quantitative works mainly studying income distribution (Li et al., 2011; Yin et al., 2014), and qualitative studies focusing mostly on procedural and recognitional justice (Friedman et al., 2018; Pascual et al., 2014; Wells et al., 2021).

The Conversion of Cropland to Forest Program (CCFP), also known as the Grain for Green Program (GFGP) is one of the largest reforestation efforts in the world. The Program was implemented by China in 1999 and it encompassed 25 provinces, affecting 32 million households and reforesting 28 million ha (Gutiérrez Rodríguez et al., 2016). Several publications investigated the socio-economic impacts of CCFP, but the results concerning most of the aspects cited above (e.g., food security, migration trend, etc.) are still mixed. Generally, income has been found to increase, as well as outmigration (Li et al., 2011), while results of food security vary widely (Delang & Yuan, 2015; Zhou et al., 2007).

The CCFP offered an opportunity to further investigate equity and equality aspects within reforestation projects with credit to its geographical size, long duration, and the variety of households involved. Most of the fairness analyses done thus far on the CCFP used narrow datasets (often just one county or a few counties within the same province). Most studies about equity within the CCFP reported aspects related to the uniformity of subsidies, that were fixed for very large areas and did not account for the different cost opportunities of farmland (i.e., income foregone by converting farmland is a function of land productivity) (Yan, 2019). Relatively few independent studies have been conducted on income inequality arising from the CCFP, and analysis of official reports provided mixed results. Bennett (2008) suggested that there is an increase in inequality among neighbours, while Liu et al. (2014) show that the CCFP contributes to a reduction in household inequality. Zhang et al. (2019) found an increase in inequality mainly due to off-farm work and capital endowments, while Li et al. (2011) identified, in Western China, a lower level of inequality within CCFP participants compared to a control group. Finally, the analysis proposed by Liu et al. (2014) seemed to support the thesis that the CCFP helped in narrowing income inequalities. This was partially due to the changes, sought and triggered by the Program, to the households' livelihood structure (i.e., a decrease in the reliance on farm income and an increase in the diversification of income sources).

Even as restoration commitments are scaling up, and despite the literature cited above, a definitive understanding of the socio-economic impacts of such activities remains unclear particularly when

related to equity or equality. This is mainly due to a lack of consistent data and monitoring, the context-specific feature of these programmes, and the long-term horizon needed to assess the impact of the restoration process (César et al., 2021).

With this paper, building on the knowledge arising from previous works, we analyzed an extensive dataset collected across three provinces representative of the two main geographic areas where the CCFP has been implemented and of the different income levels of households that participated. Moreover, we investigated the differences between equity and equality emerging within the context of the CCFP.

The word 'equity' is often misconstrued with 'equality'. Despite being incorrectly used as synonyms, they are in fact based on different principles. Equity involves the idea that everyone needs to get to a certain acceptable status of wellbeing and satisfaction, and thus, a policy aiming at improving equity will give more to people that have less (they need more to achieve that status). Equality is the concept of homogeneity, and therefore, a policy that promotes equality will be concerned with giving everyone an equal share of the benefit (Summers & Smith, 2014).

We analyzed equity by using a quintile analysis to study how households' income and economic structure change for different income-level groups. To study inequality, we first relied on the Gini coefficient, and then, we divided it to highlight the contribution to inequality from each income source. Finally, through regression-based decomposition, we can see the role of different levels of involvement in the Program, as well as socio-economic and geographical factors in the creation of income inequality.

The goal of this paper is to investigate the change in rural households' income distribution and livelihood diversification, after 12 years of CCFP implementation, through an equity and equality lens in order to provide insights into the heterogeneity of the situation of different income level groups.

To achieve this objective, we are posing the following questions:

i. How did income and livelihood diversification change after 12 years of CCFP implementation?
ii. How did income inequality and inequality structure change after 12 years of implementation of CCFP?
iii. Which are the socio-economic factors relevant for income and how do they contribute to the explained inequality?

This work contributes to the literature by providing insights regarding how inequality changed over time, and how they are related to off-farm and on-farm economic opportunities, particularly in a context where a restoration policy has been applied. Additionally, it proposes a new methodology to differentiate the analysis between equity and equality for income distribution and changes in economic structure. As the discourse around justice is becoming dominant in the context of climate and land use policies (Gadgil & Guha, 1995), such as land restoration, it becomes pivotal for scholars in this field to investigate the fairness of the processes that aim at tackling these challenges. The results provided would be needed by policymakers to adjust and refine their work, to be mindful of not exacerbating or creating social injustice. With this work, we want to emphasize the need for analytical approaches and indicators to assess fairness.

## 2 | MATERIALS AND METHODS

To study income inequality and social equity, we divided our assessment into three steps. First, we studied how income and household economic structure changed by quintile and province to identify which groups registered the largest variation as a measure of equity. Second, we calculated the Gini coefficient and the concentration coefficients (Raffinetti et al., 2017; Zhang et al., 2019) to examine how income inequality changed over time and which income source was contributing to it the most to investigate if, over time, sources that were driving inequality were able to decrease or invert their effect. Finally, we built an income-generating function to observe the impact of the level of involvement in CCFP on income level and subsequently analyzed it with a regression-based decomposition (Fields, 2003), to comprehend the extent to which income variability is due to the level of involvement in the Program.

Due to the absence of a control group, the interpretation and discussion of the results from the multi-level analysis have been supported by an extensive literature review to understand the theory of change implied (or pursued) by the Program, by numerous discussions with field experts, and by applying critical thinking on the intended inputs-outcomes causality chain suggested by the rationale behind the Program itself.

### 2.1 | CCFP background

Multiple governmental agencies were involved in the CCFP process. The CCFP target for farmland conversion was set by the State Forestry Administration, while local authorities were in charge to identify local eligible land and deliver subsidies to the household willing to participate in the Program (Yan, 2019). The original aim of the Program was to improve environmental conditions, but after a few years, it was revised to include the improvement of rural livelihoods and poverty alleviation (Bennett et al., 2014).

The compensation scheme developed within the CCFP was primarily directed towards economically disadvantaged smallholder farmers (Wang & Maclaren, 2012) living in sloping upstream areas (Gauvin et al., 2010). The subsidies were intended to cover the cost of land conversion and provide an alternative income to crop production (covering the opportunity cost) while increasing farmers' income. With this approach, the Program was encouraging a change in the households' economic structure. The subsidies ran for eight, five, or two years based on the type of land conversion (i.e., ecological forest, commercial forest, or grassland, respectively.) The subsidies in the Yellow River basin amounted to 2400 Yuan/ha, while in the Yangtse River basin, subsidies were set at 3450 Yuan/ha. After 2007 the subsidies were reduced by half, while

special funds were allocated for local investments (Delang & Yuan, 2015).

## 2.2 | Household surveys

The analysis presented in this paper relies on a 2012 survey-based dataset collected in 32 counties in Jiangxi, Shaanxi and Sichuan. These three provinces were chosen to represent the range of geographical areas targeted by CCFP (Yellow and Yangtse Rivers, upstream and downstream). The specific counties were selected to represent different levels of economic development and ensure that respondents were representative of an economic gradient that could affect the level of participation in the Program (refer to Wang et al. (2019) for further details). Finally, depending on the county size, 50–60 participant households per county were randomly selected for the implementation of the questionnaire. A total of 1800 households were mailed the questionnaire, of which 1089 were completed. Of the 1089 responses collected and filtered for missing or incomplete information, a sample of 880 households (relatively still well representative of the whole population) was included in this study.

The survey covered the following five topics: (i) understanding of the Program, (ii) reason to participate, (iii) perceived effectiveness, (iv) household suggestions, and (v) household socio-economic characteristics. This paper utilizes information about socio-economic characteristics containing data about income, income sources, capital and land endowments, numbers of labourers, education, age and, migration situation. Income data have been registered before (1999) and after (2012) the CCFP implementation.

## 2.3 | Source of incomes and quintiles analysis

We compared the income level before (1999) and after (2012) CCFP implementation, averaging it on the entire sample, by province, and by quintiles. All the monetary values have been normalized to 2010 terms and expressed in Yuan. The quintile analysis was instrumental to investigate equality and equity aspects within the program, as it allowed us to highlight differences related to changes in income and economic structure based on households' income level. The analysis of both absolute income change and percentage income change emphasizes the difference between these two concepts. In this instance, equality translates into a change in absolute income equal for everyone (meaning a higher percentage increase for the lowest-income group), while equity would result in a higher income increase for the lowest-income groups (and an even higher increase in percentage terms).

In addition to absolute and percentage-based aggregate income changes, we examined changes in households' economic structure. Households had six different possible income sources: farm income (derived from crop production for personal use and trade); forestry income (from the sale of timber and non-timber forest products); livestock income (derived by the ownership or commerce in animal or animal products); secondary sector employment income (provided by wages gained by working in the secondary sector); migratory income (remittances from family members that migrated from the county); and other income (derived by any activities that are not included in the ones above plus any subsidies households are receiving from the government). We calculated the average share of each income source (compared to total income) and the change over time and compared those changes across provinces and quintiles. In these instances, a fair project would improve the access to off-farm opportunities, and thus allow for a better diversification strategy, for lower-income level groups.

## 2.4 | Gini and concentration coefficients

We used the Gini coefficient (G) to study the total income distribution before and after the implementation of the CCFP. The Gini coefficient is a number that goes from 0 (no inequality) to 1 (complete inequality), where a decrease represents a reduction in inequality (Leibbrandt, 2000). Additionally, we relied on the concentration coefficient, or pseudo-Gini ($C_k$), to investigate the contribution of the six different income sources to inequality (Raffinetti et al., 2017). The concentration coefficient is a number that ranges between 0 and 1, which gains meaning when compared to the Gini. If the concentration coefficient for a specific income source is larger than the Gini coefficient ($C_k$:G > 1), that source is contributing to expanding inequality. Both coefficients, as well as their ratios, were calculated for the entire sample and also by province.

## 2.5 | Income-generating function and inequality contribution

We used an income-generating function to describe which demographic factors are significant in explaining income (Angelsen et al., 2014) and a regression-based decomposition approach (Fields, 2003) to decompose the income inequality in shares attributed to each explanatory variable.

We developed two models with two dependent variables: (i) total income, and (ii) land-based income. We also developed a model for non-land-based income, however, the results were not informative, and we did not report the results. Land-based income is the sum of income deriving from farm, forestry and livestock-related activities, while total income contains the land-based income plus income from remittances, secondary industry employment, and other sources. The explanatory variables for which we tested the significance were: age (1–6 representing age classes: <24, 25–34, 35–44, 45–54, 55–64, >64); education (1–6, where 1 is no school and 6 is a graduate student and above); gender; province (Shaanxi, Jiangxi, Sichuan); migration status (number of migrants per households multiplied by the average number of migration days in the same households); area of owned land (sum of farmland, forest land, and grassland, measure in $m^{-2}$); grain yield ($kg/m^{-2}$); and subsidy information (the total period (years),

the average returned area ($m^{-2}$), and average subsidies received between the first and second round (Yuan), as a proxy for the level of involvement in the program. Twenty-nine households declared zero land commitments but also reported receiving the subsidy and reported the number of years of participation in the program. We substitute these zeros with the median values of the returned areas within our sample. We preferred the median over the mean because of the skewness of the distribution of the areas. Age squared was also added to control for the possibility of a non-linear relation between income and age as suggested by the literature. Income-generating functions can assume different forms. Due to its better specification and robustness, we chose a log-linear model, and standardized the independent variables through a *z*-transformation. This allows for a direct comparison of regressors' effect, and it overcomes eventual multicollinearity issues. The general model can be represented as follows:

$$y_i = \beta_0 + \sum_{q=1}^{Q} \beta_q x_{ip} + \varepsilon_i$$

*Where:* $y_i$ is the log of the income (total or land-based income) for the *i*-th households, $x_{ip}$ is the p-th predictor for that household. $\beta_0$ and $\beta_q$ are the estimated intercept and coefficients of the model and $\varepsilon_i$ are the residuals. Because of the log-linear specification, the estimated coefficients ($\beta$s) of each regressor should be interpreted as the impact on log-income, while the impact on income will be equal to $e^{\beta}$. The logarithmic form of income is preferred due to the skewness of the data and to facilitate the application of the "Fields decomposition" that relies on the log form of income. For the regression-based inequality decomposition, we followed the methodology proposed by Fields (2003), which decomposed the explained inequality in shares (that will be indicated with $\rho$) assigned to each explanatory variable in the income-generating functions. To perform the decomposition we used the package "dineq" in R (Schulenberg, 2018).

## 3 | RESULTS

### 3.1 | Income and economic structure evolution

Household incomes on average nearly tripled (+189%) over the 12 years of CCFP, with the highest increase registered in Shaanxi (+229%) followed by Sichuan (+176%), and then Jiangxi (+92%). The difference between the income before and after the implementation of CCFP is significant in all three provinces. However, across provinces, Sichuan is the only one whose income increase is significantly different from the other two (Table S1.1). Looking at the quintiles, we registered an increase of 515%, 217%, 95%, 43%, 16%, respectively from the lowest to the highest. The absolute increase in income is statically equal across the lowest three quintiles, while the fourth and highest (fifth) significantly differ from each other and from the lowest three (Table S1.2).

The decomposition of income into its sources is representative of the households' economic structure. Overall, before the Program, the largest share of income (46%) was derived from farming activities, followed by remittances (24%), livestock income (14%), forestry activities (7%), other income (4.5%), and secondary sector employment wage (4.3%). After 12 years of program implementation, the income structure changed mainly in favour of migratory work income (+10 pp, i.e., percentage points, from 24% of total income to 34% of total income) and forestry (+10 pp). Farm and livestock income are the only two categories that decrease their share (by 20 and 3.3 pp, respectively). Other income slightly increases, too (+1.6 pp) (Table S2.2).[1]

The economic structure's changes across the three provinces were very similar to each other and were consistent with the results found in the analysis of the entire sample. Looking at the *median* value, Sichuan had the lowest number of income sources with a median change equal to zero, meaning it had the largest redistribution. On the opposite, Jiangxi registered a median share different from zero only for farming income (Figure S1.1).

The evolution of households' economic structure was common for all income-level groups, despite the stronger effects in lower income levels (Figure 1), across farming, forestry and migratory income. Farming income started at almost half of the total income (42%–48% across quintiles), but the reduction was the highest for the lowest quintile and decreased with income level (−27, −24, −19, −16, and −12 pp for the lowest to the highest quintile, respectively). For forestry income share, the shift was highest and similar in the lowest and second quintiles (+14 pp), while the third and the fourth quintiles reported a similar change at about +10 pp, and the highest quintile registered the lowest change (+4.4 pp). The livestock income share reported a unique difference across quintiles. While the lowest, second, third and fourth quintiles all showed a consistent decrease (from −3.1 to −4.7 pp), the highest quintile was the only one that increased its livestock income share (+0.2 pp). The variation in secondary sector income was not statistically significant. Regarding the overall sample, income share held by migratory work increased significantly by 10 pp. For the migratory income share, the change was the same across quintiles, even if the percentage change was greater in the lowest quintile (+76%), rather than in the highest (+25%). Finally, the other changes were not significantly different across quintiles.

### 3.2 | Income inequality and its income sources contribution

The Gini coefficient (G) for the income distribution of the entire sample decreased by 23% (from 0.46 to 0.36) across the 12 years of CFPP implementation (Table 1). Provincially, the largest Gini index decrease was registered in Shaanxi (−27%), followed by Sichuan (−22%) and lastly, Jiangxi (+0.3% and not statistically significant).

The analysis of the ratio (*r*) between the concentration coefficient ($C_k$) and G showed that, overall, before CCFP off-farm activities (i.e., income from work in the secondary sector, remittances, and other income) were the main contributors to income inequality. After

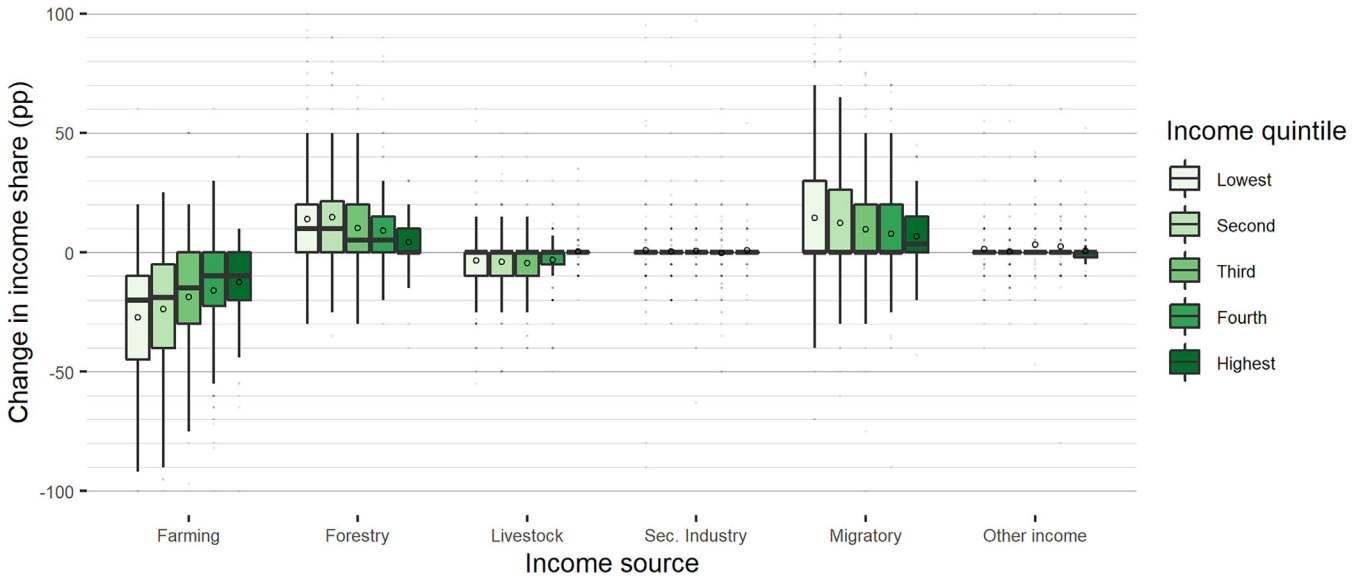


**FIGURE 1** Variation of shares of total income held by each income source before and after CCFP by quantile, measured in pp. The *y*-axis is the share difference (income share after the Program minus income share before the program), the solid bar is the median, the circle represents the average, the box itself represents the interquartile range between the first and the third quartile (25%–75%). Tables S2.1 and S2.2 in the S.I. report the numeric value of each share, before and after the implementation of the Program, and their differences with the associated statistical significance level. [Colour figure can be viewed at wileyonlinelibrary.com]

| Province | G before CCFP (1999) | G after CCFP (2012) | Change G 1999–2012 (%) |
|---|---|---|---|
| Overall | 0.46 | 0.36 | −23 |
| Jiangxi | 0.33 | 0.33 | 0.3 |
| Shaanxi | 0.47 | 0.34 | −27 |
| Sichuan | 0.45 | 0.35 | −22 |

**TABLE 1** Gini coefficient (G) of income in 1999 and 2012 for the overall sample, and for each province.

the Program was implemented for 12 years, the inequality structure remained similar. Off-farm incomes stood as the main source of inequality. However, farm income joined them in expanding inequality ($r_{farm(2012)} = 1.0$). While off-farm income's contribution to inequality expansion remained, the income from remittances and other activities (which included the government subsidies received by the households) contributed less to expanding inequality (Table 2).

In Jiangxi, forestry income shifted from contributing to inequality to reducing it. Migratory and other income played a role in increasing inequality both before and after the Program, even if other income slightly decreased its impact over time. Shaanxi was the only province in which farming income contributed to expanding inequality, with an increasing effect over time. The main contributor to inequality in Shaanxi was the income derived from employment in the secondary sector, while remittance and other income decreased inequality. Finally, Sichuan was the province that exhibited the greatest changes in inequality structure. Forestry income changed from being an equality driver ($r_{forestry(1999)} = 0.5$) to slightly contributing to inequality expansion ($r_{forestry(2012)} = 1.0$). The same dynamic was shown by the income from secondary sector activities. Income from migratory work and other income remained drivers of inequality, even if both decreased their effect (Table 2).

### 3.3 | Income-generating model and regression-based inequality decomposition

For the income-generating function, we tested for the significance of the main variables found by the literature to have an impact on income (Li et al., 2011; Wicaksono et al., 2017). Model 1 examined the determinants of household total income after the Program implementation of 12 years ($R^2 = 21\%$). Model 2 tested the significance of the same socio-economic variables for land-based income (farm, forestry, livestock combined) ($R^2 = 18\%$). The difference between total income and land-based income is the off-farm income (migratory work, secondary work income, remittances and other activities), therefore, the differences in the impact of the explanatory variables between model 1 and model 2 were due to non-land-based activities. The regressions coefficients ($\beta$) and the field-based decomposition results ($\rho$ (%)) are reported in Table 3.

Age was significant and positive only for the total income ($\beta = +0.28$), even if its effect was marginally decreasing (coefficient of the age square is negative). Education, a proxy for the quality of human capital, was significant for both total income ($\beta = +0.10$) and on-farm income ($\beta = +0.11$). The number of labourers per household was significant and positively correlated with income level, with a much stronger effect for land-based income ($\beta = +0.21$) compared to

**TABLE 2** Inequality decomposition by income source. Ratio (*r*) of the concentration coefficients ($C_k$) over the Gini index (G), for the whole sample and divided by provinces. When the ratio is larger then 1 ($r > 1$, means $C_k > G$), that income source contributes to expanding inequality.

| | Ratio (*r*) of concentration coefficients over the Gini index by income source | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $r_{Farm}$ | | $r_{Forestry}$ | | $r_{Livestock}$ | | $r_{Secondary\ work}$ | | $r_{Migratory}$ | | $r_{Other}$ | |
| **Province** | **1999** | **2012** | **1999** | **2012** | **1999** | **2012** | **1999** | **2012** | **1999** | **2012** | **1999** | **2012** |
| Overall | 0.96 | 1.02 | 0.87 | 0.81 | 0.71 | 0.74 | 1.21 | 1.27 | 1.11 | 1.05 | 1.30 | 1.14 |
| Jiangxi | 0.80 | 0.58 | 1.15 | 0.89 | 0.50 | 0.82 | 0.94 | 0.91 | 1.21 | 1.24 | 1.76 | 1.62 |
| Shaanxi | 1.10 | 1.24 | 0.92 | 0.68 | 0.65 | 0.93 | 1.32 | 1.23 | 0.88 | 0.93 | 0.88 | 0.78 |
| Sichuan | 0.69 | 0.56 | 0.49 | 1.01 | 0.91 | 0.58 | 0.79 | 1.27 | 1.37 | 1.21 | 1.42 | 1.01 |

**TABLE 3** Regression-based decomposition of income inequality.

| | Total income (model 1) | | | Land-based income (model 2) | | |
|---|---|---|---|---|---|---|
| **Independent variables** | $\beta$ | **SEM** | $\rho$ (%) | $\beta$ | **SEM** | $\rho$ (%) |
| (Intercept) | 10.08*** | 0.06 | | 9.41*** | 0.09 | |
| Age | 0.28* | 0.13 | 0.03 | | | |
| $Age^2$ | −0.29* | 0.13 | 1.6 | | | |
| Education | 0.10*** | 0.03 | 12 | 0.11*** | 0.03 | 11 |
| Province Shaanxi | −0.21** | 0.07 | 12 | −0.32** | 0.10 | 11 |
| Province Sichuan | −0.28*** | 0.08 | | −0.33** | 0.10 | |
| Number labourers | 0.11*** | 0.03 | 20 | 0.21*** | 0.04 | 26 |
| Out migration | 0.11*** | 0.03 | 14 | −0.16*** | 0.04 | 5.2 |
| Grain yield ($kg/m^{-2}$) | 0.11*** | 0.02 | 12 | 0.13*** | 0.03 | 11 |
| Land owned ($m^2$) | 0.11*** | 0.03 | 13 | 0.20*** | 0.03 | 28 |
| Average returned land area ($m^2$) | 0.24*** | 0.07 | 8.7 | 0.26** | 0.09 | 13 |
| Average area*total period ($m^2$ * Years) | 0.14** | 0.04 | 3.3 | 0.11* | 0.05 | 0.5 |
| Average area*average subsidy ($m^2$ * Yuan) | 0.92*** | 0.24 | −12 | 0.99** | 0.31 | −17 |
| Average area*total period* average subsidy ($m^2$ * Yuan * Years) | 0.60*** | 0.13 | 20 | 0.69*** | 0.17 | 21 |

*Note*: The table reports the results of the regressions and the regression-based decomposition for total income (model 1) and land-based income (model 2). The columns headed ($\beta$) report the estimated coefficients, and the stars represent the *p*-value (significance code: *p*-value<0.001 "***"; *p*-value<0.01 "**"; *p*-value<0.05 "*"; *p*-value<0.1 "). The columns headed SEM reported the standard error, and ρ is the relative weight of the independent variables in explaining inequality. The variables in each model that resulted not significant have not been included in the regression table.

total income ($\beta = +0.11$). Out-migration represents the portion of human capital that is not invested in land-based labour. It correlated positively with total income ($\beta = +0.11$) and negatively with land-based income ($\beta = -0.16$). The owned land represents the physical capital, and it correlated positively with both total income ($\beta = +0.11$) and land-based income ($\beta = +0.20$). Grain yield (proxy for productivity) had a significant and positive impact in both models, but a slightly stronger impact for land-based income ($\beta = 0.13$) compared to total income ($\beta = +0.11$). With respect to provinces, the reference level is Jiangxi, and moving from there to Shaanxi or Sichuan had a negative impact on both total income ($\beta = -0.21$ and $\beta = -0.28$, respectively) and land-based income ($\beta = -0.32$ and $\beta = -0.33$, respectively). Looking at CCFP involvement, the area of the returned land had a significant and positive effect on both total income ($\beta = +0.24$) and land-based income ($\beta = +0.26$). The interaction between returned area and total years, and returned area and unitary subsidy, as well as the interaction of all three variables, was positive and significant for both total income and non-land-based income. The unitary subsidy, the years of participation, and their interaction was not significant.

Considering the inequality decomposition, human capital (i.e., age, education, and number of labourers) was a major factor for income dispersion (identified as ρ) for both total and land-based income (20% and 26% respectively). The amount of land owned explained a larger part of the variability in land-based income (28%) however contributed to total income as well (13%). A large difference is found in the variability explained by outmigration, which accounted for 14% of total income dispersion, and for 5% of land-based. The province, level of education, and grain yield shared a similar explanation power for total income (12%), and land-based income (11%) (Table 3).[2]

## 4 | DISCUSSION

The results led to four major discussion points: (i) the difference between equity and equality and the role of off-farm opportunities; (ii) households' economic structure changes; (iii) variation in income inequality was province-specific; (iv) the positive effect on the income of the level of involvement in CCFP and its account of a large share of income inequality.

### 4.1 | Difference between equity and equality

To our knowledge, previous research on income distribution focused solely on the Gini coefficient and inequality alone. This existing body of literature seldom introduced or discussed equity, and studies that analyzed it did so from a more qualitative perspective (Wells et al., 2021). We found a clear reduction in inequality, signaled by the decline of the Gini coefficient and by the percentage change in income much higher for the lowest quintile. The analysis also suggested an improvement in equity, implied by the absolute increase in income higher for the lowest three quintiles, and a change in economic structure more marked for low-income households. Low-income groups shifted their economic structure by increasing their shares of income deriving from off-farm sources. Off-farm activities were the main driver of inequality; however, their intensity decreased over time. All these seemed to suggest that after the program, the poorest households gained access to off-farm opportunities that allowed them to increase their income, more than their richer neighbours, reducing the inequality gap. This was particularly relevant for remittances, that, despite increasing their share of total income by 50%, their contribution to inequality decreased.

Equality and equity were not one of the stated goals of the program but rather a positive (or negative) side effect. However, given the more recent goal of China (Liu, 2013) and global society (United Nations, 2015) to pursue fairness, the different impacts on these two aspects should be considered in the development of future policies. Further studies on equity and equality within restoration, or environmental policy in general, should keep these aspects in consideration, and this work is suggesting a possible methodology to investigate both the dimensions.

### 4.2 | Households' economic structure changes

The structural analysis of income suggests a change in livelihoods composition from farm work to off-farm work. This is consistent with the decrease in farming income in favour of forestry reported by Li et al. (2011) and with the panel data analysis from Uchida et al. (2009) that demonstrated a larger decrease in farm income in favour of off-farm work within CCFP participants.

As mentioned before, the low-income groups experienced larger changes in economic structure than high-income ones, particularly in relation to the reduction in farming share and the increase in remittances. This is consistent with a greater engagement of lower-income level groups in the program, as suggested by Liu et al. (2014). Of particular relevance is the shifting from land-based to off-farm work, which mainly increased the outmigration portion of income, rather than employment in the local secondary sector. Bullock and King (2011) and Zhen et al. (2014) found this same trend in their sample respectively from Sichuan and Shaanxi. Both papers explained the push factor towards out-migration with the lack of local opportunities. This point raises concern about the willingness to migrate. Migration towards more developed urban centres could give access to secondary sector opportunities and higher wages, but this would not necessarily translate into greater wellbeing. For a comprehensive analysis of the impact of migration, it is necessary to understand if it is due to improved access to this opportunity or forced by necessity. Moreover, the increase in income could have happened at the expense of other factors associated with greater land access in rural contexts, such as non-timber forest products. Furthermore, the economic structure analysis underlined the different starting situations, and thus the changes happened, across quintiles and provinces. Location specificity is consistent with the findings in Yan (2019), who showed the success of CCFP in converting low-productive hillside land in some areas compared with the undesired conversion of highly productive land in others.

### 4.3 | Variation in income inequality was province-specific

The literature reports contrasting results about the impact of the program on income inequalities. Zhang et al. (2019) reported a higher inequality level among CCFP participants compared with non-participants. However, other studies, such as Liu et al. (2013) and (2014), showed a decrease in the Gini coefficient due to the Program in the short run, followed by a small increase in the medium term. Nevertheless, all these studies were localized in a single county, and they compared two different groups at the same moment in time. Our study, instead, analyzed the same group of participants in CCFP over a 12-year time period. The lack of a control group makes the causality of CCFP on inequality changes difficult to assess. However, we can compare our inequality change, a decrease in the Gini coefficient by 23%, with the trend in this same period in the whole of China, where the inequality raised both intra and inter-regionally (+0.15 points on the calculated Gini) (Bhattacharya et al., 2018). While we are aware that causality cannot be claimed by this work, we still believe that the correlation analysis we proposed deserves thorough discussions, also to open the road for future work that will attempt to study causality in relation to not just equality but equity, as well. We showed that, over time, the lowest quintiles gained access to off-farm opportunities, that were heavily driving inequalities, and this allowed them to change their economic structure and improve their economic condition, which decreased inequality. Moreover, we know that these changes happened within a sample that participate in a reforestation Program that provided economic support while constraining land use choices.

### 4.4 | Income determinants and CCFP's contribution to inequality

The adjusted Rs-squared of our models and the signs and significance of the explanatory variables are in line with the values found in the

literature (Li et al., 2011). The province-specific results found in the quintile and inequality analysis are supported by the significant impact of the variable "province" in the models. The effect of education on on-farm income could be explained through two channels. Better education could improve farmer knowledge about agricultural practices, which can then boost productivity and increase land-based income. Alternatively, considering the role of remittances in a rural context, a better education could result in higher incomes from off-farm jobs for household members, part of which could be invested to improve farm productivity. However, the negative relationship between land-based income and out-migration suggests that the increased availability of households' cash income deriving from remittances is not used to invest in on-farm productivity improvement. CCFP involvement seems to have a positive effect on income. In particular, the returned land seemed to be the most significant variable for income level. This could be due to different factors. More converted land means greater subsidies that will contribute to increasing the income. Also, less farmland could free up labour for off-farm employment which typically generates higher income. Finally, the land converted could be a function of the land owned and thus of the general wealth of the household, suggesting not a real positive impact of returned land on income, but rather a correlation between wealth and total income.

The Fields-based decomposition is consistent with the results found by Zhang et al. (2019), the only work, to our knowledge, that decomposed the income analyzing CCFP impacts. The level of involvement in CCFP explains a quite large part of income variability (around 19%), second to importance only to the number of labourers and the land owned, which are the main production factors. Moreover, it seems to have a slightly higher explanation power for total income than for land-based income, in contrast to the results by Zhang et al. (2019). However, the authors included just the CCFP land area, leaving out the subsidy level and the years of participation, and he used a less geographically diverse sample.

## 5 | CONCLUSIONS

We found that over the 12 years under analysis, there was a reduction of inequality (−23% of the Gini index) and an improvement in equity driven by the larger enhancement of the access to off-farm opportunities experienced by low-income groups (+20% in secondary work share, +44% migratory work, +36% other income) compared to highest income group (+12%, +25%, +8%, respectively). These changes happened within the context of CCFP, which constrains the use of land for farming and grazing purposes, suggesting a correlation between the policy and the change in economic structure. There is an intriguing correlation with migration, as remittances are the economic source that gained the highest share. Even if migration contributes to expanding inequality both before and after ($r = C_k$:G = 1.1 and 1.0, respectively), its intensity decreased over time. Finally, with the regression-based analysis, we showed that the project holds explanatory power for both on-farm ($\rho = 19\%$) and off-farm income ($\rho = 18\%$), underlying the possibility of having many different transmission channels between land-use policies and income changes.

With land degradation receiving an increasing amount of attention in the international discourse due to its relevance to climate change, it is critical to not overlook its social dimension. To reverse land degradation generally implies making a shift in land use that could affect the food security and livelihood of local communities. In this work, we demonstrated how, under reforestation, the households' economic structure tends to change from land-based to off-farm activities, particularly by increasing outmigration. Even if this is true for all households, the shift is more conspicuous for lower-income groups, underlying the possibility of unequal results. As local populations are stewards of the land and vital to avoiding a fall back to land degradation, it is crucial to receive their support, with that being also related to the socio-economic benefits (or cost) associated with restoration. Ensuring the availability of alternative livelihoods for local communities could improve the rate of acceptance and support for these programmes.

Finally, in this study, we proposed a methodology to discern, in a quantitative way, the concept of equality and equity and how they can be studied in relation to land-use policies. Further research could use this methodology to develop a causality analysis.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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## ENDNOTES

[1] The percentage values may not add up to 100% due to the rounding at 2 significant digits.

[2] The percentage values may not add up to 100% due to the rounding at 2 significant digits.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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