5 Concurrent green initiatives in Fanjingshan National Nature Reserve, China

China's two large green initiatives, Grain-to-Green Program (GTGP) and Forest Ecological Benefit Compensation (FEBC) program, overlap in space in many provinces. Potential spillover effects might occur. This chapter seeks to answer whether spillover effects may exist and, if so, what are the significant characteristics of such effects and the underlying mechanisms.

5.1 Fanjingshan National Nature Reserve

We used the Fanjingshan National Nature Reserve (N27º44′-28º03′, W108º34′-108º48′), China (Figure 5.1), as our first study site to explore potential spillover effects between GTGP and FEBC. The reserve is in Guizhou province in southwestern China, with around 419 km^2. The reserve was established in 1978 as a protected area for the Guizhou golden monkey (*Rhinopithecus brelichi*) and then extended to its current size in 1986 to conserve other animal and plant species within the reserve. According to China's Wild Animal Protection Law, many of these species are listed as first-class or second-class protected wildlife species; exemplar species include the clouded leopard (*Neofelis nebulosa*) and the Asiatic black bear (*Ursus thibetanus*).

As a flagship reserve of relatively undisturbed subtropical ecosystems constituting part of the 25 global biodiversity hotspots (GDF & FNNR, 1990), the reserve is replete with over 6,000 plant, animal, and bird species (GEF Project Team, 2004). Established in 1978 and then extended to its current size in 1986, it is also home to the last and only population (around 750 animals) of the Guizhou snub-nosed monkey (also named Guizhou golden monkey; *Rhinopithecus brelichi*), an umbrella, endangered species susceptible to human presence, activity, and the resultant habitat degradation (Yang et al., 2002).

Fanjingshan has over 13,000 people who live a subsistence lifestyle, growing crops and vegetables and raising pigs and other livestock. Around 70% of these people belong to ethnic minorities, such as Tujia and Miao (GEF Project Team, 2004, p. 8). Depending on many local natural resources such as Chinese medicine herbs, fuelwood, timber, and bamboo, local people can enter non-core habitat areas to collect these resources and herd livestock. Illegal wood extraction and poaching are occasionally reported (An et al., 2020).

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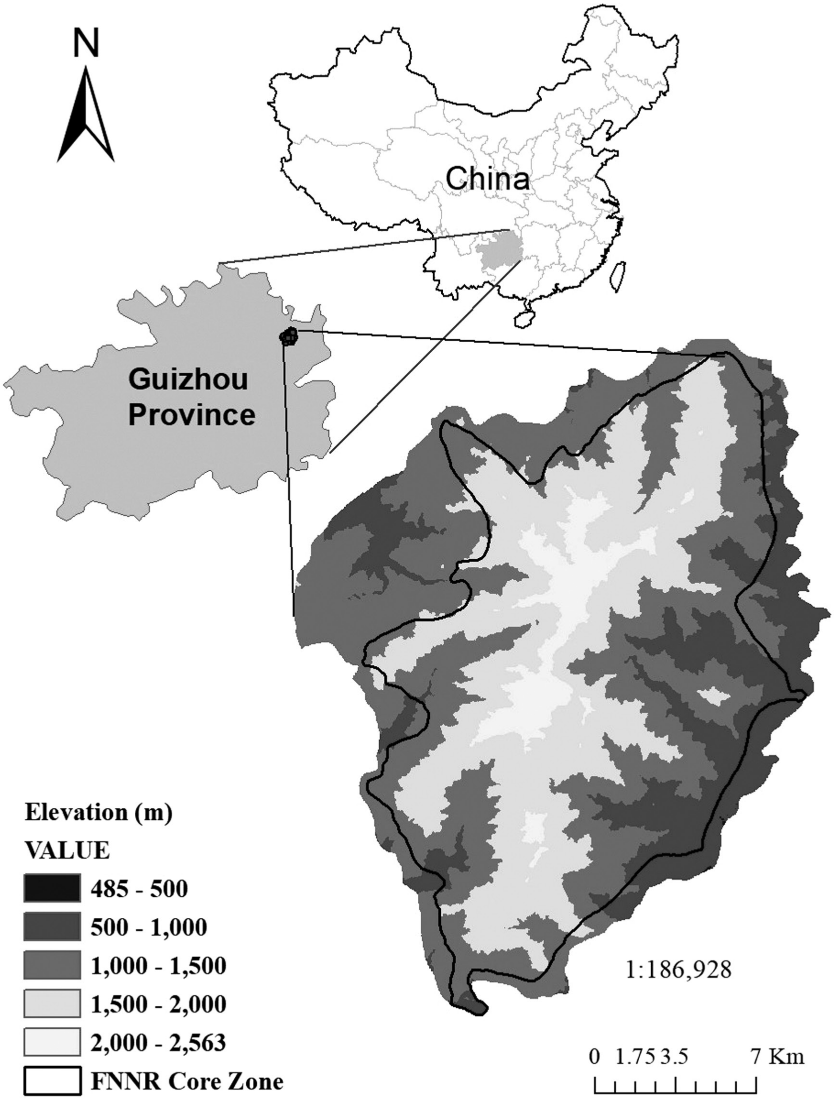

Figure 5.1 Location of Fanjingshan National Nature Reserve, China.

Like many other rural areas in China, the economic boom has led to drastic land-use changes, including deforestation and reforestation. The last decade has witnessed rapid tourism development and demographic transition—many young people migrate to cities for higher-pay jobs and send remittances to their family members left behind. Fanjingshan is a locale that implements the Forest Ecological Benefit Compensation (FEBC) and the Grain-to-Green Program

(GTGP). Fanjingshan initiated the GTGP program around 2000, at which time 774 households, primarily inside the reserve, enrolled land parcels in the program. In Fanjingshan, farmers planted pine, Chinese fir, bamboo, and other species with the local government's seedlings. Fanjingshan started FEBC in 2002, using government funding for local people's patrol of designated forests (there was no forest enterprise at Fanjingshan due to its nature reserve status). FEBC money was either paid to individual villagers or allocated to local communities such as administrative groups. Local people, including Fanjingshan officials, primarily hold a favorable view toward FEBC and GTGP, crediting them to improve the local environment and promote wildlife conservation.

5.2 Data collection

We used a stratified random sampling strategy to select households for interviews in 2014 and 2015 (An et al., 2020; Yost et al., 2020). Our sampling frame was a roster of all 3,256 households, which was based on the census of Fanjingshan in 2013. An administrative village is comprised of several natural villages (also named villager groups or resident groups). A villager group is mainly equivalent to a "production team" made up of closely knit households in charge of cultivating collective cropland before implementing the Household Registration System in the early 1980s.

We subdivided the whole 3,256 households into 123 sampling units, out of which we randomly selected 58 units. We randomly assigned these 58 sampling units to 20 administrative villages within or across Fanjingshan boundaries. The sampling units' assignment was in proportion to each administrative village's population size, while smaller administrative villages were slightly over-represented in our sample. Then at each administrative village, we took a random sample according to the number of sampling units it received on a 20 households per unit basis: if an administrative village received an assignment of one unit, we then randomly selected 20 households for an interview; if two units, then 40 households, and so on.

This sampling strategy ended up with 1,160 households pre-selected as our sampling pool, more extensive than our intended sample size of 650. This choice was due to various practical challenges such as the inability to find a knowledgeable person in a household, the absence of household members due to travel or outmigration, or unwillingness to participate in our interview. We eventually managed to complete the entire survey of 605 households in 2014. We skipped the content of our 2014 survey as our paper does not use its data.

Since some households remained unreachable (e.g., no knowledgeable member available at the time of our visit), we ended up with a survey of 494 households in 2015. The survey questionnaire consisted of three sections: (1) household land-use; (2) participation in GTGP, FEBC, and other programs, if any; and (3) household time allocation, amount of harvest, and cash income (if sold), and gross cash incomes from various activities. Specifically, we inquired about detailed land use, including the total area of dryland and paddyland, the portion of land enrolled at GTGP, walking distance from home to each plot, and the productivity of these plots before or after GTGP.

We also mapped all relatively big (greater than 0.1 mu) GTGP and non-GTGP plots on Google Earth and converted them into regular GIS shapefiles. We chose three plots from GTGP land, representing the farthest, medium, and closest plot to the household, and similarly chose three more plots from non-GTGP land in our sample. Then for each selected plot, we asked their willingness to enroll or reenroll (if already in GTGP) under a set of hypothetical conditions regarding GTGP payment level, duration, post-enroll land-use options, and neighbors' attitudes toward GTGP (Yost et al., 2020).

In the 2015 survey, we inquired about detailed information on their reserved and responsible forestland, called "self-maintained and responsibility mountains", respectively, that may receive FEBC payments. The former refers to the small parcel(s) of forestland assigned to the household before China's rural reform in the early 1980s (Krusekopf, 2002), while the latter refers to the forestland (usually much more extensive in size) allocated to the corresponding household after the rural reform. We collected detailed data about the area, geographic location (via Google Earth), resource collection, amount of funds received, and patrol efforts (frequency, time, etc.). We also collected information about participants' willingness to patrol under a set of hypothetical policy conditions (i.e., patrol frequency, compensation level, and neighbor's willingness to patrol). For more information about the variables, see Table 5.1.

5.3 Modeling the amount of land enrolled in GTGP

We modeled the total area of land enrolled in the GTGP by a household (GP_TL_Amt) as a function of the variables listed in Table 5.1 (not including plot level data) using OLS regression. The independent variables (Table 5.1) in our model were selected based on the Sustainable Livelihoods Framework, in which human, social, natural, physical, and financial capitals that a household possesses play a crucially important role in relevant livelihood decisions (United Nations Development Programme, 2017). We did not collect data for physical capital (such as access to road, clean water, information, and affordable energy) as they do not vary substantially in our study area.

At Fanjingshan, GTGP was implemented earlier than FEBC. In addition, local farmers had more freedom to participate in GTGP or decline it, while FEBC participation was largely government-prescribed. We thus choose GTGP enrollment land as the dependent variable and FEBC land as an independent variable with control of several other variables. The regression takes the following form:

$$y = b_0 + b_1 X_1 + \sum_{j=1}^{k} c_j CV_j + e \qquad (5.1)$$

where y is the area of cropland enrolled in GTGP, X_1 is the area of land enrolled in FEBC, CV_j are the controlled variables that represent influences from a set of

Table 5.1 Definition and descriptive statistics of variables at Fanjingshan, China

Variable name	*Definition (unit)*	*Min*	*Max*	*Mean*
GP_TL_Amt	Area of land the household enrolled in GTGP (mu)	0	15	2.38
lgGPTLLd	Logarithm of GP_TL_Amt[a]	−13.85	2.71	−3.28
FstMnyAmt	Annual FEBC payment a household receives (1,000 yuan)	0	3.67	0.58
lgFstMnyAmt	Logarithm of FstMnyAmt	−13.82	1.30	−4.99
DryLdAmt	Amount of dryland the household has (mu)	0	22.5	2.67
LgHDryLd	Logarithm of DryLdAmt	−13.82	3.11	0.38
PadLdAmt	Amount of paddyland the household has (mu)	0	20	3.47
LgHPadLd	Logarithm of PadLdAmt	−13.82	3.00	0.06
HhCshInc	Household cash income in 2014 (1,000 yuan)	0	1230.97	60.59
LgHCshInc	Logarithm of HhCshInc	−13.82	7.12	2.91
AllFstAmt	Amount of FEBC forestland the household has (mu)	0	1215.00	18.36
LgFstAmt	Logarithm of AllFstAmt	−13.82	7.10	2.91
HH_Size	Household size (# of people in the household)	1	9	3.20
HHLbr	Household labor (# of people with age from 15 to 59 years)	0	6	2.21
PlotInGP	Plot already in GTGP (1 for yes and 0 for no)	0	1	0.40
Plot_Dst	Distance from plot to the household (minutes of walking)	0.08	270.00	23.24
Plot_Area	Area of plot (mu)	0.05	15.00	0.77
Plot_Mny	Hypothetical amount of GTGP pay (100 yuan)	1	7	4
Plot_Span	Hypothetical amount of GTGP span (years)	4	12	7.99
Fallow	Land parcel left fallow (0 for not and 1 for fallow)	0	1	0.25
NB_Pct	Percent of neighbors agreed to join GTGP (percent)	25	75	49.15

Note:
[a] Some households have extremely large numbers. Taking a logarithm makes the associated variables less skewed and more appropriate for later regression analysis. All the variables with the name beginning with Lg are such logarithm-transformed variables.

carefully chosen household-level capitals, c_j the coefficients of these variables, and e the residual.

Human capital is represented by household size (HH_Size), household labor (HHLbr), and the amount of land allocated to the corresponding household during the time of the household responsibility contract system around 1980 (Krusekopf, 2002). The area of dryland (DryLdAmt) and area of paddyland (PadLdAmt) represent natural capital. We differentiated dryland and paddyland as the former may be farther away from households, in sloping areas, and more likely subject to GTGP enrollment. These two areal land measurements are essential as they determine—at least affect—available land supply and food security for a household (Joshi, 2011; Yost et al., 2020).

For social and/or financial capitals, we first considered concurrent PES policy, which was found to affect households' behavior (Yost et al., 2020). Since local villagers were not involved in FEBC decisions (the local government essentially determined who may enroll and how much land should go into enrollment), we only examined whether and how the amount of FEBC payments (FstMnyAmt) or area of forestland enrolled in FEBC (AllFstAmt) may affect GTGP enrollment (GP_TL_Amt) when controlling for a set of relevant variables. We selected the FEBC compensation amount (FstMnyAmt) and the amount of enrolled land (AllFstAmt). Note that the FEBC payment amount (FstMnyAmt) and land amount (AllFstAmt) were not highly correlated ($r=0.0972$, $p=0.10$); therefore, we included both in the regression without much concern about multicollinearity. Second, we used an income variable, i.e., household cash income (HHCshInc), to represent the impact of financial capital. To reduce the potential adverse effects of a skewed distribution (Lo & Andrews, 2015; Olivier et al., 2008), we also calculated the logarithm of these variables (Table 5.1).

Following relevant literature (Chen et al., 2009a, b) and our work earlier (Yost et al., 2020), we included several variables that represent plot-level characteristics, including plot enrollment in GTGP before 2015 (PlotInGP), distance from plot to the household (minutes of walking; Plot_Dst), area of the plot (mu; Plot_Area), hypothetical amount of GTGP pay (100 yuan; Plot_Mny), hypothetical period of GTGP enrollment (years; Plot_Span), and whether the plot would be left fallow if it were enrolled in GTGP (0 for not and 1 for fallow; Fallow). To explore the impacts of social norms, we included a variable, the percent of neighbors who would agree to join GTGP (NB_Pct), following relevant literature (Chen et al., 2009a, b) and our previous work (Yost et al., 2020). Note that these plot-level variables (i.e., from PlotInGP to NB_Pct; Table 5.1) are only applicable to our modeling of the willingness to enroll land in GTGP under a set of hypothetical policy variables.

Examining the regression results (Table 5.2), we found that FEBC payment (FstMnyAmt), a variable representing concurrent payments for environmental services, exerted a significant impact on the area of land enrolled in GTGP (coefficient=0.4487, $p=0.0644$, significant at $\alpha=0.10$ level). For reasons behind this relationship, we refer to Yost et al. (2020) and Section 6.4 where we found similar results at Tianma National Nature Reserve (Chapter 6).

5.3.1 Modeling the logarithm of the amount of land enrolled in GTGP

Many stark differences between households made the data difficult to analyze. These households were extremely rich or poor, had a very big or small area of dryland, paddyland, or FEBC forestland, or received very high or low FEBC payments, making related data very skewed (see Table 5.1). We, therefore, analyzed

Table 5.2 Regression results for GTGP at Fanjingshan, China

Variable	*Description*	*Coefficient*	*p-value*	*VIF*
Intercept	—	0.4469	0.2686	0
DryLdAmt	Dryland amount	0.5839	<0.0001	1.0830
PadLdAmt	Paddyland amount	0.2737	<0.0001	1.0438
HHCshInc	Household cash income	−0.0017	0.2692	1.0423
FstMnyAmt	FEBC payment amount	0.4487	0.0644	1.1026
HH_Size	Household size	0.1530	0.2710	2.3787
HHLbr	Number of laborers (age between 15 and 59)	−0.1295	0.5461	2.3700
AllFstAmt	FEBC forestland amount	−0.0014	0.4675	1.0751
R^2 (Adjusted R^2)	0.3827 (0.3666)			

Note: This model does not have the logarithm change of variables; the dependent variable name is GP_TL_Amt.

Table 5.3 Modeling results for the logarithm of GTGP (lgGPTLLd) at Fanjingshan, China

Variable	*Description*	*Coefficient*	*p-value*	*VIF*
Intercept		0.5253	0.0009	0
LgHDryLd	Log of dryland area	0.2735	<0.0001	1.0317
LgHPadLd	Log of paddyland area	0.1298	0.0003	1.0269
LgHCshInc	Log of cash income	−0.0440	0.1054	1.0354
LgFstMnyAmt	Log of FEBC payment	0.0162	0.0755	1.0253
HH_Size	Household size	0.0873	0.1008	2.3919
HHLbr	Number of laborers (age between 15 and 59)	−0.0383	0.6405	2.3889
LgFstAmt	Log of FEBC forestland area	0.0121	0.2970	1.0373
R^2 (Adjusted R^2)	0.2123 (0.1918)			

the data after a logarithmic transformation of the independent variables to avoid potential problems arising from skewed data and the disproportional impact of significant outliers on regression results (Lo & Andrews, 2015; Olivier et al., 2008). The results are in Table 5.3.

The impact of FEBC land area did not change after the logarithm transformation: it was still a positive predictor (coefficient = 0.0162) and significant at $\alpha = 0.10$ level ($p = 0.0755$; Table 5.3). Also, interestingly, household size and household labor are both insignificant. We also see decreases in R^2 and adjusted R^2 due to the logarithm transformation. All these changes in regression results confirmed our concern that outliers may change regression results to a considerable extent. Despite such an influence, the impact of the concurrent PES program (log-transformed FEBC payment: coefficient = 0.0162, $p = 0.0755$; Table 5.3) remained significant, suggesting a similar significant coefficient (coefficient = 0.4487, $p = 0.0644$; Table 5.2) was not an outcome due to data skewness. Later in Section 6.4, a similar outcome arose from Tianma National Nature Reserve, confirming this spillover effect.

5.3.2 Modeling the impact of FEBC payment on willingness to enroll land in GTGP

We also modeled the willingness to enroll in GTGP under a set of hypothetical conditions using the discrete choice modeling technique. According to Lancaster's approach to consumer theory, attributes determine the utility of certain goods or services rather than the goods or services per se (Lancaster, 1966). According to this theory, the stated preferences (regarding participation in GTGP) from our household interviews can be modeled based on a random utility model (RUM) specification (McFadden, 1974). The RUM is potent for quantifying the preferences of individuals when they make decisions of choosing a particular product or service from a finite set of alternatives. A simple operating assumption exists that the service or product chosen by the consumer yields the highest utility among all alternative services or products available in the corresponding choice set. This model is powerful in our situation because the respondents had to choose one out of two alternative decisions: either participating in the GTGP or not given a set of controlled variables (Yost et al., 2020). Similar modeling efforts can be found elsewhere (Chen et al., 2009, b).

In light of this insight, we collected data about several key GTGP program attributes during our interviews of 605 households in 2014 and 494 households in 2015. The data collected in 2015 and the discrete choice model we developed in this paper were very similar to those in 2014, and we refer to Yost et al. (2020) except for the difference discussed below.

The results based on the survey data in 2015 (Table 5.4) were mainly consistent with those from the 2014 survey (Yost et al., 2020) despite a substantial difference in the questions we asked. In the 2014 survey, a respondent was presented with a hypothetical scenario regarding GTGP policy features. Hypothetical conditions included combinations of a randomly chosen value for payment (Mny), payment span (Plot_Span), post-enrollment land-use choice (fallow, planting cash trees, or planting ecological trees), and neighbors' choice regarding GTGP participation (NB_pct). After being presented with the hypothetical scenario, then the question was formed: "under this combination of hypothetical values, would you be willing to enroll *part of your farmland* in the assumable GTGP?" The question did not target a specific parcel of the land.

In 2015, we selected a set of farmland plots, including those already enrolled in GTGP and ones not enrolled yet at the survey time. Then for each specific plot, we asked the following slightly modified question: "under this combination of hypothetical values, would you be willing to enroll *this specific farmland plot* in the assumable GTGP?"

Under various hypothetical conditions, local villagers still considered the area of available dryland a critical, positive predictor (0.0989; $p = 0.0446$; Table 5.4) for the GTGP enrollment decision, but not paddyland (0.0612, $p = 0.1221$; Table 5.4).

Table 5.4 Modeling results of the impacts of FEBC on GTGP at Fanjingshan, China

Variable	*Description*	*Coefficient*	*p-value*
Intercept		−1.5041	0.0015
DryLdAmt	Dryland amount	0.0989	0.0446
PadLdAmt	Paddy land amount	0.0612	0.1221
HHCshInc	Household cash income	0.0008	0.5219
FstMnyAmt	FEBC payment amount	0.0471	0.8045
HH_Size	Household size	−0.1273	0.4588
HHLbr	Household labor	−0.1058	0.3418
AllFstAmt	FEBC forestland amount	−0.0028	0.0658
PlotInGP	Plot already in GTGP	0.9544	<0.0001
Plot_Dst	Distance from plot to household	0.0115	0.0003
Plot_Area	Area of plot	0.0630	0.5256
Plot_Mny	Hypothetical amount of GTGP pay	0.1827	<0.0001
Plot_Span	Hypothetical amount of GTGP span	0.0479	0.0556
fallow	Land parcel left fallow	−0.2898	0.0921
NB_pct	Percent of neighbors agreed to join GTGP	0.0121	0.0028
2 Res Log pseudo-likelihood		5,781.79	
Gener. chi-square/DF		0.72	

Note: The model is also called discrete choice modeling, where the dependent variable is My_Choice (1 for yes and 0 for no for whether to enroll the asked parcel in GTGP or not).

This result may come from the minimal paddyland supply and its importance in maintaining food security. Household cash income was still insignificant in the discrete choice model (0.0008, $p=0.5219$; Table 5.4). Household size and labor availability were insignificant ($p=0.4588$, $p=0.3418$, respectively; Table 5.4), as in the case for modeling current GTGP land (Tables 5.2 and 5.3).

At the plot level, our discrete choice model confirmed the positive impact of GTGP payment on GTGP participation: Each 100 yuan/mu of GTGP payment increased the odds of cropland enrollment in GTGP by 20% ($e^{0.1827}=1.20$ or 120%) when other relevant variables were in control (coefficient=0.1827, $p < 0.0001$; Table 5.4). Distance from the parcel to the household (Plot_Dst) and whether a plot was already in GTGP (PlotInGP) at the survey time were both positive predictors, suggesting that if a parcel was farther away or already in GTGP, it was more likely to be enrolled in GTGP. The plot area (Plot_Area) was insignificant, which is understandable as the parcel area might not bear significant importance. The remaining plot-level variables, i.e., hypothetical amount of GTGP time span (Plot_Span) and the land plot left fallow (fallow), had coefficients consistent with those in Yost et al. (2020), and we thus skip their discussion. Worthy of mention is the significant coefficient of the percent of neighbors who would agree to join GTGP (NB_pct; coefficient=0.0121, $p=0.0028$), suggesting a certain household's decision to participate in GTGP is highly affected by neighbor decisions. This finding confirms the important effects of social norms (Chen et al., 2009, b).

For every additional mu of FEBC land (AllFstAmt), there is a 0.3% (0.0028; Table 5.4) decrease in the odds of enrolling GTGP because the odds ratio is $e^{(-0.0028)}=0.9972$. We explain the offsetting impacts of FEBC payment by livelihood strategies under land scarcity: when deciding to enroll additional cropland in GTGP in 2015 (i.e., at the time of the survey), their remaining cropland was relatively scarce (the villagers had the opportunity to enroll a portion of their land in 2001 or later years). Payments from FEBC may offer them cash otherwise available through other sources such as outmigration or enrolling more land in GTGP. Furthermore, food security may be another concern when deciding to enroll some of their cropland (Yost et al., 2020).

We can prove that when the original probability (i.e., the probability before a change in a particular variable occurs and leads to the change in odds) is small, the change in probability is very close to the change in the corresponding odds. Therefore, we conclude that each additional mu of FEBC land should lead to a decrease of 0.30% in the probability of their GTGP land enrollment due to each additional mu of FEBC. At Fanjingshan, the median FEBC area is 10 mu (0.67 ha) (in comparison to 1.5 mu or 0.1 ha, median GTGP land area at Fanjingshan), which can generate a 10 × 0.30% or 3% decrease in the likelihood of enrolling more land.

5.4 Ecological co-benefits of FEBC program

According to Liu et al. (2013), the total accumulative forestland and grassland due to the implementation of GTGP in China reached 8.80 million ha by the end of 2009. As the total area of GTGP land started to level-off in 2005 (Liu et al., 2008), we assume that China has GTGP-induced farmland and grassland at the magnitude of 8.80 million ha, which is the amount in 2006. We only consider returned cropland and grassland because the portion for barren land does not apply in our situation. Next, we aim to find the total area of farmland out of 8.80 million ha.

According to Wu et al. (2019), the increase of grassland in the Loess Plateau (the Plateau's total area is 625,000 km^2), China, due to GTGP between 2000 and 2015, was 5,235.38 km^2. For the same reason, as mentioned above (level-off of GTGP-induced land since 2005), we consider the Loess Plateau has 5,235.38 km^2 of GTGP-induced grassland, which equals that in 2006.

According to China's National Bureau of Statistics, its total grassland in 2011 was 393 million ha (3,930,000 km^2). Due to the stability in grassland between 2006 and 2011, we consider that China had 3,930,000 km^2 of grassland in 2006. Assuming the countrywide percentage of grassland converted from cropland is the same as that in the Loess Plateau, China should have gained a total of [5,235.38 × 3,930,000/625,000] = 32,920.07 km^2, or 3.29 million ha grassland in 2006. Therefore, China's total farmland conversions to forestland due to GTGP was 8.80 − 3.29 = 5.51 million ha, or 82.65 million mu (1 ha = 15 mu).

As mentioned in Sections 4.1–4.3 (regarding China's two major PES programs), a total of 104 million ha (1,560 × 10^6 mu) of FEBC land was protected in 2006. The consequent annual compensation should then be [1,560 × 10^6 mu ×

9.75 yuan/mu] = 1.5210×10^{10} yuan. Note that for collective or individual-owned FEBC forestland, the compensation was 9.75 yuan/mu.

Our results show that each 1,000 yuan of FEBC payment increased the area of land enrolled in GTGP by 0.4487 mu (Table 5.2), indicating a rate of 4.4870×10^{-4} mu/yuan. Therefore, the total "additional" area of GTGP land due to FEBC payment is (1.5210×10^{10} yuan) $\times$ 4.4870×10^{-4} mu/yuan = 6.8247×10^{6} mu, or 6.8247 million mu. Note that in the mid-1980s, China launched the Classification-based Forest Management system, which was a precursor of the later FEBC (Dai et al., 2009). Out of the total 82.65 million mu of farmland due to GTGP as of 2006, 6.8247 million mu came as a co-benefit of FEBC payment, corresponding to 8.25% of total GTGP land.

Next, we look into the case of Tianma (more detail in Chapter 6). Every 100 mu of FEBC land would generate 0.47 mu more GTGP land (Table 5.4), indicating that each mu of FEBC land would lead to an additional 0.0047 mu of GTGP land. The FEBC pay rate was 8.75 yuan/mu in Tianma, then the rate is [$1000 \times 0.0047/8.75$] = 0.54 mu per 1,000 yuan. Given that the total FEBC land was 104 million ha ($1{,}560 \times 10^{6}$ mu) in 2006, the total additional GTGP land enrollment caused by FEBC was $1{,}560 \times 10^{6}$ mu $\times$ 0.0047 = 7.3320×10^{6} mu, or 7.3320 million mu. This amount, which came as a co-benefit of FEBC payment, was 7.3320/82.65 = 8.87% out of 82.65 million mu GTGP forestland in 2008. This result is slightly larger than the above amount based on Fanjingshan results. Therefore, the average co-benefit of GTGP enrollment in China due to FEBC payments is approximately 82.65 million mu $\times$ (8.87% + 8.25%)/2 = 7.0748 million mu, which is 0.4717 million ha.

Next, we estimate the reduction in carbon sequestration due to the relationship between GTGP and FEBC. According to Feng et al. (2013), the average annual net ecosystem production (NEP) of woodland in the semi-humid forests was 304.40 g C m^{-2}. Our study site Fanjingshan is in a subtropical climate zone with higher carbon biomass. To derive a conservative estimate (e.g., to be used as a lower bound), we still use the rate of 304.40 g C m^{-2}.

As shown earlier, the FEBC payments have induced an additional enrollment of 6.9343 million mu or 0. 4717 million ha of GTGP land by 2010. The increase in carbon sequestration is estimated to be:

0.4717 million ha $\times$ 304.4 g C m^{-2} = $0.4717 \times 1{,}000{,}000 \times 10{,}000 \times 304.40$ g C m^{-2} = 143.5850×10^{10} g C = 1,435,850 million t C = 1,435.850 billion t C (1 t = 10^{6} g)

Next, we calculate what may arise under the hypothetical GTGP policy. Following the same rationale, the FEBC-induced reduction in potential GTGP land if implementing GTGP under the hypothetical conditions was 3.0%, as shown in Section 5.3, which translates to 5.51 million ha (China's total GTGP land) $\times$ 0.03 = 0.1653 million ha. The corresponding loss in carbon sequestration is:

0.1653 million ha $\times$ 304.4 g C m^{-2} = $0.1653 \times 1{,}000{,}000 \times 10{,}000 \times 304.40$ g C m^{-2} = 50.3173×10^{10} g C = 503,173 million t C = 503.173 billion t (1 t = 10^{6} g).

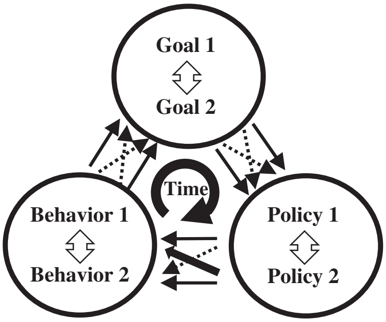

Figure 5.2 Cross-program spillover effects at Fanjingshan, China. The diagram is modified from Figure 1.3, where the solid one-way arrows stand for internal influences from one element to another within the same initiative, while the dashed one-way arrows and double two-way arrows for potential spillover effects; the circular one-way arrow represents Time–Time spillover effects. The big, bold arrow represents the spillover effect with evidence from this section.

5.5 Summary

Fanjingshan National Nature Reserve features a strong *Policy–Behavior* spillover effect, represented by a positive impact of FEBC payment (*Policy* 2) on GTGP enrollment (*Behavior* 1); This effect is represented as the big, bold arrow in Figure 5.2. Extrapolating the average rate to the whole country (for their spatial concurrency in China, see Table 4.1), China should have received 6.93 million mu (0.4623 million ha) "additional" GTGP farmland as an FEBC-induced co-benefit, which could have translated to 1,407,241 million metric tons of carbon sequestration per year under a conservative estimate. However, this positive *Policy–Behavior* spillover effect may turn into a negative one if more land is to be enrolled in GTGP in the future (i.e., under the hypothetical conditions); i.e., the FEBC payments will likely reduce possible enrollment in GTGP by 0.1653 million ha, corresponding to a reduction in carbon sequestration by 503,173 million metric tons.

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