The assessment framework of the Returning Farmland to Forestland/Grassland policies - a case study of Loess Plateau in Shaanxi province, China

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To improve the still worsening ecological conditions and reduce the soil erosion, the central government of China initiated the policies of Returning Farmland to Forest/Grassland (RFFG) which have converted 28.47 million hectare of farmland to forest in 25 provinces since 1999. However, increase in forest coverage does not necessarily mean an improvement of ecological conditions as well as accretion of provision of ecosystem services. Moreover, a drastic land use change can have substantial impacts on social and economic systems for the locals through a various channels. In this paper, we attempt to structure the causal relationships of relevant factors in sustainable development to examine the effects of the policies on human well-being particularly for Shaanxi province, the province that has been regarded as the best performer among those provinces in China. This paper first overviews the RFFG policy and its background. We then present an assessment framework in the context of Shaanxi province through the examination of the Millennium Ecosystem Assessment Framework developed by the United Nations. We address the local context in terms of ecological and social components in particular. We then construct a data base through local and provincial information sources corresponding to the assessment framework. We demonstrate that the RFFG policies increased some of the ecosystem services such as flood control and carbon storage and sequestration. We also show that substantial social changes occurred in particular areas in Shaanxi while the policies led to the improvements in economic conditions on average across the province.

Keywords: *Returning farmland to forestland/grassland, Ecosystem, Assessment, Shaanxi*

1. INTRODUCTION

The economic reforms have brought great benefits to the coastal region in China since 1978, an enormous socioeconomic gap between the east and west regions was formed. With an expansion of human activities through urbanization and income growth, huge areas of farmland had changed into built-up areas till 2000 in Yangtze River delta[1)], which indirectly and directly impacted ecosystems in China. Those land use change increased the magnitude and scale of flood damages. The 1998 extreme flood disaster in the Yangtze River delta drastically changed regional ecological conditions. For example, soil erosion attributed to the flood affected nearly fifty percent of the whole China's land area and damages in the west region were particularly severe. To conserve and recover the ecological conditions, the Chinese government explicated Six Key Forest Conservation Program (including the Natural Forest Conservation Programs (NFCP) and the Returning Farmland to Forest/Grassland (RFFG)) in the 10th Fifth-Year -Plan in China.

NFCP aims to reduce soil erosion; however the most important contributor to this erosion is farming operated on lands with steep slope[2)]. Particularly, the west region comprises 70% of the steep slopes in the whole China. To complement the effort of the NFCP, improve the ecosystem conditions and provide the sound human well-being to the local people in west region in China, RFFG was initiated in 1999.

This paper proposes an assessment framework for those policies by clarifying the causal relations in elements of human and ecosystems, by focusing on the case of Shaanxi province which is a still underdeveloped province in the west region in China.

Fig. 1 illustrates the location of Shaanxi province and provinces where the RFFG policies have been implemented. Among the provinces in the program of RFFG, Shaanxi province is the first one in which the RFFG policy was implemented and has achieved the best result among these 25 provinces. Soil erosion in Shaanxi province has been very serious; the affected area in Shaanxi accounts for 20% of the soil erosion in the whole China.

Specifically, this paper first investigates the RFFG and NFCP policies as well as the local conditions. Then we construct an assessment framework in the context of Shaanxi province through the examination of the Millennium Ecosystem Assessment Framework[3)] developed by the United Nations (UN). We address the local context in terms of ecological and socioeconomic components particularly in Shaanxi Province; including vulnerability, biodiversity, Engel's Coefficient, and cultural and political components. We then construct a data base through local and provincial information sources corresponding to the assessment framework. We demonstrate that RFFG policies increased some of the ecosystem services such as flood control and carbon storage and sequestration. We also show that substantial social changes occurred in particular areas in Shaanxi while the policies led to the improvements in economic conditions on average across the province.

2. OVERVIEW OF RFFG ASSESSMENT

(1) Policy Overview

RFFG was first carried out in three pilot provinces of Shaanxi , Sichuan and Gansu in 1999 and it was gradually expanded to 17 provinces in 2000 and finally to 25 provinces (including autonomous, regions and municipalities) in 2003 in China **(Fig.1)**. Currently, about 32 million farmer households with 124 million farmers are involved in the program.

Fig.1 25 provinces including Shaanxi where RFFG is introduced

Table 1 summarizes the aim, target and payment programs of RFFG. RFFG mainly aims at conserving the ecosystem such as recovery of the vegetation areas and reducing soil erosion through increasing forest coverage in the west region in China etc, while improving the local socioeconomic development.

There are three types of the vegetation in RFFG; the ecological forest, economic forest and the grass. Farmers whose arable lands are converted to forestlands/grasslands receive compensation through monetary payment and tax exemption. The payment details are listed in **Table 1**.

RFFG program focuses on the western China because of its ecological and social vulnerability and geological characteristics (i.e., mountainous). This region has severe erosion; 179 million ha of land is desert. Erosion area in the western region accounts for about two-thirds of erosion area in the whole China.

(2) Consequences - National level

On the surface, RFFG have achieved enormous effects on the ecological system. The forest coverage has increased from 16.55% in 1999 to 20.36% in 2009 in China and the total area of RFFG have reached 28.47 million hector (ha) in 2010 **(Table 2).** From 1999 to 2005, the large arable land has converted into forestland/grassland. Although it does not include all the target farmlands with steep slope, the RFFG plan was suspended in 2007 (and resumed in 2008).

On the other hand, agricultural production in the provinces in which RFFG was implemented increased even though arable land has decreased while

Table 1 Returning Farmland to Forestland/Grassland

Aim	・Conserve ecosystems such as recovery of the vegetation areas ・Protection of vulnerable ecosystems and biodiversity ・Reduce soil erosion through increasing forest coverage ・Improve local economic development ・Alleviate poverty through central governmental economic support and adjustment of the local rural economic structure ・Reform the local development and maintain social stability
Content	・Convert cropland with steep slopes (>25%) and abundant lands suitable through afforestation to ecological forestland, economic forestland or grassland. ・The proportion of ecological forestland is to be over 80% to the whole RFFG area.
Subsidy payment	Payment for Food: ・In theYangtze River Delta: 2,250kg grain /ha (or 3,150 Yuan/ha) ・In theYellow River Delta: 1,500kg grain /ha (or 2,100 Yuan/ha) Payment for miscellaneous expenses: 300 Yuan /ha per year Payment for seed or seedlings: one-time subsidy of 750 Yuan/ha Subsidies duration : 8 years for ecological forest, 5 years fotr economic forest, and 2 years for grass land

Table 2 Area of returning farmland to forestland/grassland in China（Unit: 10^4ha）

	1999～2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
China	230.33	572.87	713.33	679.47	377.80	26.70	stop	133.00	33.16	80.00	2846.66

other provinces showed a decrease in agricultural production in the same period. This means that substantial growth in agricultural productivity occurred in the target regions. It is reported that soil erosion was generally controlled under the RFFG plan. In 1999 land areas affected by desertification increased by 3,436 km^2 however in 2009 turned out to be decrease by 1,283 km^2 in the target regions[4].

Consequently, these land-use changes generated different effects in the regional ecosystems. It is reported that rainfall increased in the northern region, resulting in reinforcement of ecosystem services provision capacity, including adjustment functioning, water and carbon storage of forest.

Moreover, RFFG policies affected socioeconomic conditions of local farmers through investments and subsidiary payments. By the end of 2010, 267.5 billion Yuan was already spent in the RFFG. The total investment in the RFFG is projected to reach a total of 435.3 billion Yuan in the future. Specifically, 1.24 hundred million Farmers have obtained 141.3 billion Yuan for food aids and 180 million Yuan for miscellaneous expenses, which accounts for 10% of farmer's total income. The series of RFFG intervention affected industrial structure and improve the local social development. For example, programs that aim at the enhancement of women's status have been conducted[5].

3. ASSESSMENT FRAMEWORK FOR RFFG IN SHAANXI

(1) Assessment framework

Assessment of an environmental conservation policy requires careful consideration as numerous components are usually interacted. Implementation of a policy affects directly and indirectly the target components and other components in socioeconomic and ecological systems. Moreover, exogenous factors that are irrelevant to policy intervention affect relevant components. It is thus important to figure out causal relations among related components in a systematic manner. Having such a framework in hand, it becomes feasible to differentiate the effects of policy from those from exogenous factors. This section presents an assessment framework for RFFG in Shaanxi and demonstrates a quasi assessment based on it.

The Millennium Ecosystem Assessment (MA) that is carried out by the United Nations is to understand the complex mechanisms and interactions between different systems addressing the importance of ecosystem services[6, 7]. In this paper, we show an assessment framework and corresponding data base for Shaanxi province based on the MA by taking into account the conditions and characteristics of RFFG and Shaanxi.

Fig. 2 illustrates causal relations among ecological and socio-economic components for the assessment of RFFG in Shaanxi. As explained in Section 2, the goal of RFFG is to enhance the socio-economic conditions (i.e., well-being of the local people) through improvements of local ecological conditions. These components are shown in the right-center of the figure as a consequence of other components. Notice that each of the components in the two systems interacts with one another: dependency of local livelihood on the ecosystems through various services is an example.

On the other hand, causal components as stressors, stresses or impacts are drawn in the left side in the figure. The impact components both of socioeconomic and ecological systems are further categorized by scale. As global drivers, globalization and climate change might enter in the assessment framework. At national level, macroeconomic change and national policies including RFFG are listed. These elements are considered as human driver forces, directly/indirectly affecting socioeconomic and local ecological conditions in the form of environmental and social perturbations. Finally, the magnitude of those perturbations on the local conditions varies depending on the vulnerability and resilience as well as the local socio-economic and ecological conditions.

Status of each element in the components is evaluated through relevant indicators. For example, household consumption of a farmer can be thought of as an indicator to represent a social condition of the local people. The framework shows that many factors affect this well-being indicator; not only ecological conditions for the household which affect their agricultural production and thus consumption level, but socio-economic conditions such as macroeconomic situations as well as policy intervention directly/indirectly impact their consumption.

In this study, we also constructed a data base mainly at Shaanxi province level. We collected more than 55 indicators regarding socio-economic and

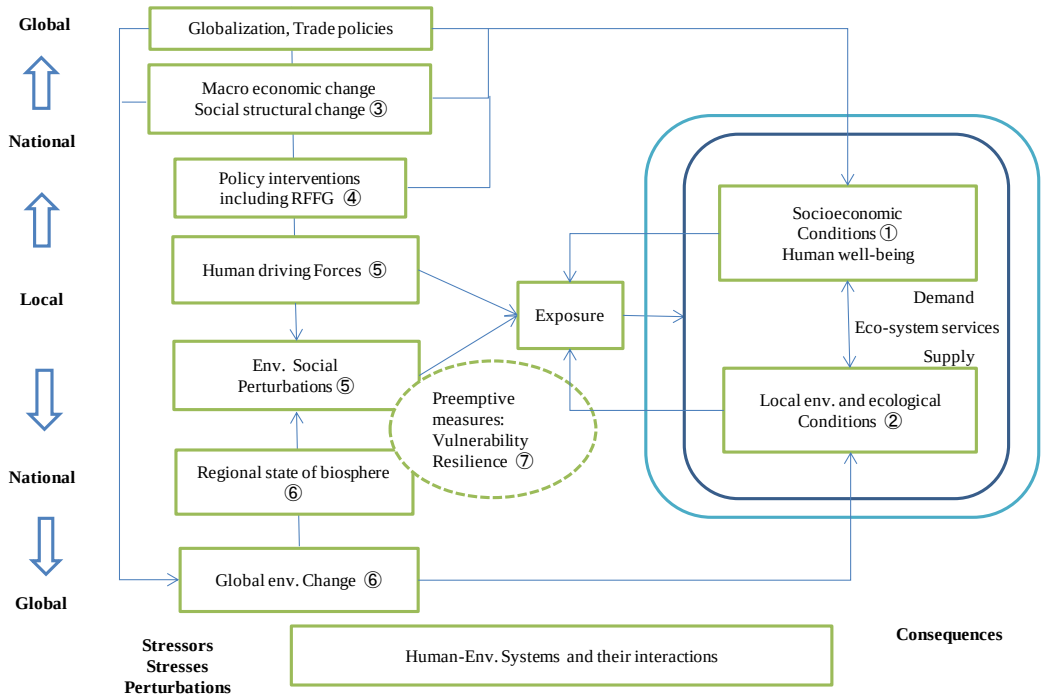

Fig. 2 Assessment framework for RFFG in Shaanxi - causal relations of socioeconomic and ecological components

ecological systems. Table 3 reports the indicator definitions and results in 2000 and 2009. We categorized these indicators so that each indicator corresponds to the components defined in the assessment framework. Although it is neither a quantitative nor sophisticated one, next subsection demonstrates a quasi assessment using the framework and some indicators in the data base.

(2) Assessment

Shaanxi is one of the first provinces where RFFG was implemented. The area of Shaanxi is 163,228 km^2 with population of 36.18 million. Water deterioration and soil erosion is a critical issue in Shaanxi: it is reported 128,000 km^2 was affected by erosion mainly due to land use and erosion in Shaanxi accounted for 20% of the erosion area in China[8].

RFFG has brought large effects on land use through the conversion of farm land in mountainous areas into forest and grassland since 1999. According to the Forestry Department of Shaanxi Province, the accumulated afforestation area through RFFG in Shaanxi is one million ha as of 2009 (**Table 3**), which is the largest among the 25 provinces. The forest coverage in Shaanxi increased from 30.92% in 1999 to 37.26% in 2009 (**Table 4**). Additionally, RFFG attempted other measures for erosion control including establishing conservation zones mainly in Loess Plateau in Shaanxi[9]. As a result, amount of eroded soil in Shaanxi was substantially reduced from 8.3 million tons in 1999 to 4.0 million in 2009. Likewise, sandy and desert areas were decreased by 120,000 ha and 24,000 ha, respectively.

Afforestation and conservation areas also generated impacts on the local ecosystem system. Comparing 1999 with 2009, annual growth in living wood and stock of biomass increased by 12 million m^3. The capacity of carbon storage and sequestration also increased by 20 million t-CO_2. As of 2010, the Shaanxi's forest storage is 360 million m^3, which ranks the 10th in China. Furthermore, this positive impact is estimated to last in the following decades. Pengwenying et al. show that carbon storage in Loess Plateau could account for 19.2% of Chinese total carbon storage after in 2030 (Currently, it only accounts for 1.16%)[10]. Finally, although greater details have to be investigated, some biodiversity indicators also show improvements: population of Qinling

Table 3 Area of returning farmland to forestland/grassland in Shaanxi（Unit: 10^4ha）

	1999～2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Shaanxi	11.53	25.37	28.20	15.22	7.65	4.91	3.35	2.26	3.43	-	101.92

Table 4 RFFG results in Shaanxi (2000-2009)

System	Category 1	Category 2	Unit	Indicator	2000	2009
Socio-economic	③	Population	10^4 people	Population	3644.00	3772.00
	③	Economy	Billion Yuan	GDP	180.40	816.98
	③	Economy	Industrial structure	Primary	258.22	789.64
				Secondary	782.58	4236.42
				Tertiary	763.20	3143.74
	③	Investment	10^4 USD	Used foreign investment	28842.00	151053.00
			Yuan	Per capita total investment in fix asset	2046.80	17373.80
			%	Proportion of the science and technology occupied to total GDP	2.10	2.90
	①③	Income	Yuan	Disposable income of urban residents per capita	5124.00	14129.00
				Income of rural residents per capita	1470.00	3438.00
				Per capita GDP	4950.60	21659.07
	①③	Transportation	km	Railway density	0.01	0.02
			km^2	Road density	0.21	0.70
	①	Education	Yuan	Per capita education expenditure	318.10	1430.00
			Person/10^4 people	# of university student	66.00	237.00
	①	Employment	Person	Employment	4948020.00	5991545.00
	①	Utility	%	Urban water consumption rate	96.50	98.10
				Gas distribution rate	74.50	89.60
	①	Health	Doctor/10^4 people	# of physician	18.00	16.00
			Bed/10^4 people	# of hospital bed	25.00	35.00
	①	Housing	m^2	Housing area in urban area per capita	16.08	20.95
				Housing area in rural area per capita	22.87	30.38
	①	Communication	Per 100 person	Ratio of people using telephone	9.67	21.61
				Ratio of people using cell phone	4.25	61.97
	①	Consumption in urban areas	% to total expenditure	Food (Engel's Coefficient)	35.80	37.30
				Clothing	9.40	11.30
				Other goods	43.80	41.90
				Housing	11.00	9.50
	①	Consumption in rural areas	% to total expenditure	Food (Engel's Coefficient)	43.50	35.10
				Clothing	6.60	6.20
				Other goods	33.90	37.90
				Housing	16.00	20.80
Environment	②⑤	Land use	%	Vegetation coverage	56.90	68.90
			%	Forest coverage	30.92	37.26
			Million ha	Forest area	1.89	7.60
	⑤⑦		10^4 ha	Decreased the desertification area during the ten year	12.60	
			10^4 ha	Decreased sandy land area during the ten year	2.07	
	②		Hector	Arable land area per capita	0.09	0.08
	⑤⑦		Hector	Rural practitioners per capita arable land area	0.31	0.33
	⑤⑦	Soil	%	Ratio of severe Soil erosion area	54.80	13.40
	①②⑥	Soil	10^4 ton	Agricultural production	1089.00	1164.90
	②⑦	Biomass	Million m^3	Living wood growing stock increased per year	12.00	
	⑦		Million t-CO_2	Carbon storage and sequestration per year	20.00	
	②⑦	Biodiversity	# of population	Crested Ibis numbers	7.00	1000.00
				Increased Qinling giant panda	273.00	
	⑤	Water	%	Ratio of the industrial wastewater treatment before discharge	82.00	96.50
	⑤⑥	Climate	Day	# of sand storm day per year	66.00	24.00
			mm	Precipitation	588.40	660.30
			Degree in Celsius	Average temperature	15.00	15.10
	①⑤	Energy/Climate Change	10^4ton carbon equivalent (TCE)	Total energy production	3805.00	27563.00
				Total energy consumption	2617.00	8255.00
			TCE /10^4Yuan GDP	Energy consumption	1.45	1.20
			Ratio	Elasticity coefficient of energy production	0.77	1.53
				Elasticity coefficient of energy consumption	0.12	0.62

Data sources: Shaanxi Statistic Yearbook 2001, 2010. Category 1 corresponds to the numbers in Figure 2.

giant panda and Crested Ibis increased.

Notice that RFFG implementation led to substantial arable land loss for agricultural production in Shaanxi. The speed of arable land loss in Shaanxi (11% decreased) was in fact faster than national average (6.4% decreased) between 1999 and 2009. However, this farm land loss did not much affect agricultural production (**Table 4**) because of agricultural investment and increase in agricultural productivity. Although it is not included in the framework of RFFG, this sort of integrated approach resulted in the balance between conservation of the environment and protection of the local socioeconomic conditions.

Finally, we look into the impacts of RFFG on the socioeconomic conditions. The center government

has invested about 32 billion Yuan into the Shaanxi RFFG. There are 9.7 million farmers engaged in the RFFG. The RFFG have contributed the local socio-economic development.

First, we note that during the RFFG period, China experienced unprecedented economic growth. In Shaanxi, GDP per capita increased from 4,600 Yuan to 15,160 Yuan in 2009 in 2004 price. The industrial structure also changed substantially. The GDP share of the primary sector was 16% in 1999 and became 9.67% in 2009. The largest and growing sector in Shaanxi is now the secondary sector, which accounted for 52% of GDP. These growth and changes indeed much improved socio-economic conditions as shown in **Table 4.**

Having an observation of these macroeconomic indicators, the results in **Table 4** suggest RFFG yet played a crucial role in improving farmer's economic conditions. Of course, monetary compensation directly increases their income and consumption level. However, comparing urban and rural consumption on food shows that the share of consumption on food in rural area substantially decreased between 1999 and 2009 while that of the urban household increased in the same period. Usually, when income increases, the share of food consumption decreases. One potential reason for this adverse observation can be attributed to a sharp increase in food price. The RFFG payments scheme indeed helps households in rural areas challenge inflation.

4. DISCUSSION

RFFG is a large scale policy that affects both ecological and socio-economic conditions of the locals as well as the whole China. On the surface, RFFG through afforestation and erosion management improved many ecological conditions. The payment scheme for involved farmers positively affected the local economic conditions as well.

Yet, RFFG has potentially caused and will cause undesirable consequences. First, a thorough investigation of how afforestation affects biodiversity and provision of ecosystem services is necessary at a case study level. Base on a field study, Cao et al. reported that afforestation in the northern Shaanxi could increase water stresses, adversely affecting the number of species and local agriculture[9]. Furthermore, planted forest usually requires management. Without effective forest management, planted forest will lose its capacity to provide ecosystem services. As Dai et al pointed out, the local governments have already faced social, financial and scientific risks in forest management[11].

Finally, our data base lacks information on socio-economic state of individual farmers. Dai et al. reported that the subsidiary payments to the framer are insufficient as compensation or to catch up price increase, which induces some farmers to return to their original place for farming[11]. Also, the RFFG possesses only a monetary compensation scheme. Programs such as capacity building and education are necessary for farmers' adaptation to a new environment. Our future research will include household survey to investigate individuals' well-being and its relation to local ecosystem conditions.

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