The Impact of Environmental Policy on Household Income and Activity Choice: Evidence from Sandstorm Source Control Program in North China

Wei Zhang*, Can Liu[**1]

*Department of Agricultural Economics, Michigan State University,
East Lansing, MI 48824-1039 (zhangwe9@msu.edu)

** China National Forestry Economics and Development Research Center, No. 18 East Street Hepingli, Beijing, 100714, P. R. China (liucan196608@yahoo.com)

Selected Paper prepared for presentation at the American Agricultural Economics AssociationAnnual Meeting, Providence, Rhode Island, July 24-27, 2005

[1] Wei Zhang (zhangwe9@msu.edu) is a Ph.D. candidate, Department of Agricultural Economics, Michigan State University, East Lansing, MI 48824-1039, USA. Can Liu (liucan196608@yahoo.com) is Associate Professor and Deputy Director of China National Forestry Economics and Development Research Center, Beijing, P.R. China.
The authors thank John T. Giles at Michigan State University and Hongfa Ren at State Forestry Administration of China for stimulating discussions.

ABSTRACT

This paper uses household data to assess the near-term impact of the program on incomes and activity choices of rural households in areas where the sandstorm control program (Beijing and Tianjin Sandstorm Source Control Program) was implemented. Central to our analysis is a unique panel survey conducted by the State Forestry Administration covering years from 1998 to 2003 in 17 counties in three Northern provinces Hebei, Shanxi, and Inner Mongolia (autonomous region). The essential feature of the program is an annual subsidy provided to participating farmers to cover costs associated with permanent retirement of farm land and the planting of saplings. We first look at the impact of program participation on household incomes and, not surprisingly, observe a positive relationship. Next we look at the impact of the program on the activity choice of farm households. We found evidence that 1) participating households are more likely to engage in off-farm wage employment than self-employment activities after retiring farmland, and 2) participating households are diversifying income away from farming to more non-agricultural activities. These findings may suggest that 1) farmland retirement payments may have helped farm households overcome credit constraints preventing them from starting their own businesses, and 2) the program may have contributed to re-shaping the structure of rural household production in a way that household labor supply is slowly moving from farming to non-agricultural sector such as self-employment and off-farm wage employment.

Keywords: environmental program, impact, household income, activity choice, farmland retirement payment, sandstorm, desertification

1. INTRODUCTION

Sandstorm is one of the most catastrophic phenomenons to occur in North China that originates mostly in arid and semi-arid areas of Northwest China (Food and Agriculture Organization 1997, Ye 2003). Featured by gale-blown thick sands and dusts in the air, darkened sky, and poor visibility, it brings disastrous consequences to human livelihood and economy. In recent years, the rapidly increasing frequency, scale, and intensity have made sandstorm one of the most concerned environmental problems in North China (Ci 2004, He and Xiao 2003, Ye 2003). While global climate changes over the past century and the unique geography and topography of Northwest China have provided the catalysts for the formation of sandstorm, land desertification has been identified as the root of the problem, and human activities (such as over-cultivation, over-grazing, misuse of water resources, and deforestation) remain the most blamed reason for the increase of decertified land in China (Zhu and Wang 1993).

To tackle soil erosion and desertification and eventually reduce sandstorm attacks on the Beijing and Tianjin metropolitan areas, the Chinese government initiated the "Beijing and Tianjin Sandstorm Source Control Program (BTSSCP)" in 2000 that prescribes an array of conservation practices to address different types of agricultural land and production activities in three northern administrative regions: Hebei province, Shanxi province, and Inner Mongolia Autonomous Region (IM)[1], a major origin of sandstorm in China (China Internet Information Center 2004a, Reuters 2002). One of the major conservation prescriptions is known as the "farmland retirement program" that pays rural households to set aside their working farmland and grow trees on them. Over a

[1] In addition to the two provinces and one autonomous region, the BTSSCP also aims to improve the soil condition in seven suburban townships surrounding two municipal cities Beijing and Tianjin.

ten-year period of time from 2001 to 2010 (2000 is the pilot year) and with a planned budget of 55.87 billion CNY[2] (US$6.75 billion) (China Internet Information Center 2004a), the program targets 75 counties and townships in North China, promising to convert 2.63 million hectares of ecologically fragile farmland to woods, afforest 4.94 million hectares of land, and cover 10.63 million hectares of land by grass by 2010 (China Internet Information Center 2004a). Given the temporal and spatial scale of the program, especially the substantial rural population that is affected by the program, it is therefore of great interest to assess the socio-economic impacts of the program on household income as well as how households are adapting their production activities during the early transition period.

The Chinese government has actively engaged in combating erosion and desertification since the 1980s, and the success and magnitude of China's effort has been well-documented (Rozelle et al. 2000). While the environmental and productivity outcomes of these efforts have been widely studied (see Food and Agriculture Organization, 1997 for a bibliographic study of experiences in China), very little is focused on the socio-economic impacts on other outcomes of interest such as poverty mitigation and household activity choice except a recent series of studies on China's land set-aside program (known as "Grain for Green") (Uchida et al. 2004, Uchida et al. Forthcoming, and Xu et al. 2004). Xu et al. (2004) studies the conflict that may exist between conservation and food security. Uchida et al. (2004) and Uchida et al. (Forthcoming) evaluate the cost-effectiveness and sustainability of the Grain for Green program and examine its impact on poverty alleviation in rural areas. The key findings from Uchida et al. (2004) and Uchida et al. (Forthcoming) include: 1) the program has

[2] US$1 ≈ 8.2765 CNY in 2004

been moderately successful in achieving its poverty alleviation objectives, in particular, although poor households in rural China were not disproportionately targeted, they have benefited from increased asset holdings, 2) there is only weak evidence that participating households have begun to shift their labor into the off-farm sectors, and 3) there is room for better targeting plots that are susceptible to soil erosion.

The relationship between development and environment in developing countries has often been seen as a “conflict” (e.g. Jan 1995) in the sense that the two goals may compete with each other for limited resources. Notwithstanding, development and environment are both priorities and one objective should not come at the expense of the other at least in the long term. Theoretically, conservation programs that aim to curb resource and environmental degradation can contribute to poverty alleviation (and vice versa), which is a profound policy challenge to the developing countries. This challenge is especially obvious in China where land and other natural resources are already under unprecedented pressure from its enormous population and economic development. On one hand, environmental degradation adversely affects 400 million people (Food and Agriculture Organization 1997) and causes direct economic losses of 54 billion CNY (US$6.6 billion) each year in China (China Daily 2003).On the other hand, rural population accounts for 64% of the total population in China, of which 26.5% live in households with consumption or income per person below the World Bank US$1 per day poverty line, nearly 133 times of their urban counterparts (National Bureau of Statistics of China 2003, World Bank 2004). Environmental degradation is particularly costly for the poor (Freeman et al. 2005) because they reply more on natural resources for their primary income, and thus are more vulnerable to any productivity changes associated with the implementation of environmental programs. The poor are further worse-off if the up-front and long-term costs occurred due to the participation are not compensated by the government or monetized though market channels.

This paper uses data from a unique panel survey conducted by the State Forestry Administration of China (SFA) in 17 counties of North China covering years from 1998 to 2003. Using household data supplemented with village and county-level survey data, this paper attempts to achieve two objectives: 1) to assess the immediate/near-term impact of the program on incomes of rural households in areas where the sandstorm control program was implemented, and 2) to explore the impact of the program on the activity choice of farm households with specific interest in identifying possible association between agricultural concentration and program participation as well as how households have responded to the program with adaptive behavior towards diversified income composition. trends and evidence for household activity choice before and after the program adoption In addition, the impacts of demographic factors such as household size and education of the head of household are examined after controlling for village and county natural and economic condition variables (such as weather, poverty rate, average yield, and agricultural price index). The results will provide useful information to the continuing implementation of the program in its next 5-year phase while benefiting the design and implementation of future environmental policies.

Following this introduction section, we provide an overview of the sandstorm problem in China and some key features of the BTSSCP in Section 2. Section 3 describes the data and the econometric methods used for the analysis. In Section 4, we report the results and findings on income effect of the program and trends and evidence for household activity choice before and after the program adoption. Section 5 concludes.

2. SANDSTORM AND DESERTIFICATION IN CHINA AND THE BEIJING AND TIANJIN SANDSTORM SOURCE CONTROL PROGRAM

Among China's natural resource problems, erosion and desertification have the greatest impact on GDP (Rozelle et al. 2000). Land desertification encompasses over 30% of the total land territory and adversely affects 400 million people in China (Food and Agriculture Organization 1997), causing direct economic losses of 54 billion CNY each year (China Daily 2003). Apart from some natural causes such as drought and wind that drive the desertification process, human activities such as over-cultivation, over-grazing, over-collection of fuel wood, misuse of water resources, and deforestation, are responsible for an estimated 94.5% of the total area of sandy desertification in China according to Zhu and Wang (1993). Of all the deserts and decertified land in China, those formed during geologic ages account for 77.6% and those formed due to human activities make up 22.4% (China Internet Information Center 2004b), implying that human societies of modern time have rapidly altered the natural ecosystems, leaving them more vulnerable to any natural processes.

Given the scale of the problem and insufficient national financing, land desertification in China is worsening (Food and Agriculture Organization 1997). While the local impacts of desertification are primarily landscape change and depressed economy due to the gradual loss of land fertility, desertification process could also lead to large-scale social and ecosystem alterations that are far beyond the locality. For instance, desertification in the worse scenario could generate large-scale migration and "environmental refugees" (Cardy 1993), which might stress out the economy and ecosystems of the receiving regions if their accommodation capacity fails to keep up with the population expansion.

Sandstorm weather was first recorded in China in the 14th century and had maintained low in frequency until the 18th century. Since then, sandstorm occurrence has presented an exponentially increasing rate, especially in the past 50 years (Ci 2004). While only 5 sandstorms took place in the 1950s, 14 and 20 were recorded in the 1980s and 1990s, respectively (Ci 2004). The problem continued to rise sharply after we entered the new millennium, reaching 68 times during a four-year period from 2000 to 2004 with the record of 18 times reported in 2001 (See Table 1). It was in the spring of 2000 that the unprecedented frequency (16 times) and intensity of sandstorms started catching great attention from the public and the government officials and eventually led to the initiation of a strategic plan that targets sandstorm problem specifically as BTSSCP.

While the direct impacts of sandstorms on humans include life loss, heath problems (such as respiration system disease and eye irritation), transportation and telecommunication problems (such as highway accidents and airplane navigation difficulty), assets loss (such as livestock and crops being blown away), and damages to infrastructures, sandstorms also indirectly affect humans' wellbeing through damaging the important components of ecosystem such as surface soil loss, sand sediments, vegetation cover destruction, and water and air quality deterioration. For instance, with a wind over Force 12, the sandstorm in May of 1993 killed 85 and injured 264 people, causing an estimated direct economic loss of 550 million CNY; more than four thousand houses were destroyed, about 120,000 animals died or went missing, and about 373,333 hectares of crops were destroyed (Ci 2004).

Under the principle of "government direction and voluntary participation", the central government of China and its agencies had taken the sole role of program planning. Based on the recommendations of ecologists, the government not only specified the instruments and implementation manners of the program, but also assessed proposals submitted by targeted counties. From this perspective, the BTSSCP is a central-planned and -administered environmental program, in which conservation targets and goals are set in a top-down fashion. Although counties identified as "hot spot" may have less freedom to decide "in" or "out", they are allowed to negotiate benefits with the central government. In general, the voluntary rule is well followed for two reasons: 1) the payment scheme has been set so "generously" that people find it lucrative to participate, and 2) some poverty alleviation loans/funds by the central government are bundled up with the participation of the BTSSCP and counties/villages authorities would find it a "win-win" situation to join the program. According to our county sample, 18% of the counties activated the farmland retirement practice in 2000, 35% started in 2001, and 47% started in 2002. By province, 3 out of 5 representative counties in Hebei and all 4 representative counties in Shanxi introduced the program in 2002, 6 out of 8 representative counties in IM introduced the program in 2001. Unsurprisingly, the timing of introduction at the village level spreads out even more. Figure 1 shows the average intensity of program participation (annual new retired farmland).

The BTSSCP prescribes a variety of practices including farmland retirement, afforestation, grass management, livestock management, ecological immigration, etc. to address different types of agricultural land and production activities. This study focuses on the adoption of farmland retirement due to its central role in the program. Other practices such as grassland management and livestock management are not widely applicable and thus their impacts might be less significant and harder to measure.

The main features of the farmland retirement program include: First, when the program is available in the community, households set-aside active farmland permanently and plant trees on them. In return, government subsidizes the adoption with crop, cash, and sapling purchasing money. The rates of subsidies are set uniformly for crop subsidy at 100 kg per mu[3] per year (converted in cash value using current year prices), cash subsidy at 20 CNY per mu per year, and sapling purchase money at 50 CNY per mu[4]. The time span of subsidy is determined by the final use of the afforestated land. Specially, crop and cash subsidies are based on accumulated area of farmland retirement and typically last 5 years if the afforested forests are designated for commercial use and 8 years if designated primarily for providing ecological services[5]. Sapling purchase money is a one-time supply when new retirement and plantation take place. Second, retirement involves farmland that has been contracted to farmers under the "Household Responsibility System" for certain years (usually 30 years). This type of land differs from collectively-owned barren land for which afforestation program is in place as well (see further discussion in Section 3). Third, farmers and are eligible for harvesting forestry products from the retired-and-afforested land subject to rules and regulations.

[3] One mu is equivalent to 0.165 acre or 0.067 hectare.
[4] Although set specifically in the official plan, in some cases these subsidy rates deviate moderately from the official rates according to our sample. Reasons behind these variations, however, are not known to us and are not the focus of this paper. (Speculations include misuse of the appropriation to finance other uses, insufficient appropriation, delayed payment, transactions costs, and so on.)
[5] Crop and cash subsidies can be extended beyond the program-specified period to accommodate verifiable individual need.

3. DATA AND METHODS

The survey was conducted by the SFA in three strata: 17 counties were first randomly selected to represent the population of 68 program-targeted counties in Hebei, Shanxi, and IM, from which 18 villages were drawn with each representing its belonged county (with the exception of Balinzuoqi county in IM where two villages were selected); and finally, a total of 188 households were sampled from the selected villages with a total of 927 observations covering 1998 to 2003. The actual data were collected in 2003 and 2004 in a retrospective way. Survey participants in 6 counties were not able to recall information for all previous years, which leads to an unbalance panel for our final dataset. Statistical test finds no significant difference between the full unbalanced panel and the balanced sub-panel. Since the reason we have missing years for some households is not correlated with the idiosyncratic errors (i.e., no systematic sample selection bias), unbalanced panel causes no problems to the estimations since most econometric packages make the appropriate adjustment for the loss of degree of freedom (Wooldridge 1999). Table 2 shows that overall the sample provides a good representation of the population with observations reasonably distributed across the region.

The dataset reports 7 major categories of information: household demographics, forestry production, program participation, program benefit (including subsidy payment and afforested forest-generated income), household income, household production investments, and household labor input. On average, households earned an annual per capita net income of 1903 CNY during the survey period, with 6.74% related to the BTSSCP and 93.26% generated by household production. Within the household production income category, farming accounted for 49.50%, followed by off-farm income (15.40%), other income (13.28%), and livestock income (13.25%). The majority of the program-related income came from government subsidies (97.42%) of crop and cash. The sapling subsidy payment was offset by forestry investment because the money was used right away for purchasing afforestation inputs. Although income generated on newly afforested land only accounted for 2.58% of total program- generated benefit by the year of 2003, we expect it to pick up rather rapidly once the afforested forests are ready for commercial harvesting.

Using Welch's approximation formula, heteroskedasticity-robust t-test is performed to compare income levels across both temporal and spatial dimensions (see Table 3). By province, per capita income was significantly different across three provinces. Specifically, IM households on average earned a per capita income of 2,100 CNY, followed by Hebei (1,842 CNY), and Shanxi (1,422 CNY), only 68% of that for a typical IM household. Among the three provinces, Shanxi received the highest amount of per capita program-generated income (274 CNY), accounting for 19% of overall income compared to only 139 CNY or 7% of overall income in IM and 154 CNY or 8% in Hebei. In fact, households in Shanxi received almost twice as much program-generated income as their counterparts in IM, indicating a considerable provincial difference in terms of income composition and program adoption. Using village-level crop yield as an approximate measure of land productivity, Shanxi is found slightly better-endowed than IM (by 9%). This seems contrasting to the general expectation that regions with better land condition would retire less land. Further data mining finds that a better explanation may lie in the heterogeneous production structures between the two provinces. At the household level, livestock and farming production brought 386 and 2,003 CNY of income, respectively, to a typical family in Shanxi, whereas these two sources contributed almost four times of livestock income and 1.7 times of farming income to a household in IM. This implies that in IM, farmers may have less incentive to retire low quality farmland because of their diversified household-economy, whereas farmland was far more of an important production input for households in Shanxi so that they were more inclined to take advantage of the government program.

By year, per capita household income in average presented an upward trend during 1998 to 2003 (see Table 3). The growth rates, however, were not significant for consecutive years during 1998 to 2001 but started to rise significantly since 2002. In fact, 32% and 26% of income growths were observed in 2002 and 2003 relative to 2001 and 2002, respectively. While per capita household production-generated income only increased by 23% and 12% in 2002 and 2003, respectively, the expansion of program-generated income reached 243% and 150%, boosting the earnings in these two years. Meanwhile, the proportions of household production-generated income had dropped from 96% in 2001 to 90% in 2002 and 80% in 2003. Equivalently, shares of program-generated income increased from 4% to 10% and 20% over the same period. This is not a surprising finding given the fact that the farmland retirement wasn't widely adopted until 2002 (risen by 94.41% relative to 2001). Since government subsidies of crop and cash were based on accumulative retired land, by 2003, 93% of households had adopted the program and they as a whole were receiving considerable amount of subsidy payments. Therefore, we argue that the income growth in the region had been stagnating prior to 2001 with slow and insignificant increases but started to rise rapidly since 2002 largely benefited from program participation. The econometric analysis in the next section will quantify this proposition, in particular, examining the impact of farmland retirement on household income.

Selection bias which occurs when pre-existing conditions skew outcomes in a way that is not truly attributable to the program intervention bias is a major challenge to measuring program impacts in non-experimental settings (Freeman et al. 2005). In our case, variable that are endogenous choice of the household (e.g. program participation) may be influenced by production conditions observed by the households, but unobserved by the econometrician, and thus be correlated with the error term in the regression and cause a bias (Pender 2005). Assuming the unobserved factors are time-invariant (which is likely to hold), one approach to address the endogeneity bias problem is to use fixed effects (FE) estimation. The strength of FE estimation is that is controls for unobserved fixed factors that could confound the estimation and the weakness is that the fixed factors may pick up the effects of variables of interest, eliminating or weakening the ability to identify those effects (Pender 2005). Another common approach is to use instrument variables (IV's) or two-stage least squares estimation. The validity of this approach is often limited by the ability to find good IV's. In addition, even if the IV's are relevant and the exclusion restrictions of the model are valid, IV estimation may be inferior to Ordinary Least Square (OLS) if the endogenous explanatory variables of concern are not actually correlated with the error term in the regression (Pender 2005).

There are two explanatory variables at the heart of this paper: 1) a dummy variable for program participation (PROGRAM) with a value of 1 for participation and zero for non-participation, and 2) an annual indicator of new participation intensity

“Annual New Retired Farmland (NRFL). Correlation between unobserved factors and the two interested explanatory variables is the central concern throughout the estimations. After performing robust OLS and FE estimations, we try out our model with an IV candidate “time of program introduction at the village level (VILLINTRO). VILLINTRO is not likely to correlate with household unobserved fixed factors while at the same time might be closely related to household program participation.

Another issue that may complicate our assessment is the overlapping presence of another environmental program known as the “Bare wasteland afforestation policy (ABL)”. The ABL is an ongoing national forestry policy that aims to plant vegetation on collectively-owned barren and wasted land. The key difference between ABL and farmland retirement is that ABL is mandatory and not subsidized by the government aside from sapling supplies and partial labor compensation. Unlike farmland retirement program that takes working land out of production, converting barren and wasted land to forestland literally incurs no opportunity cost of land use. To integrate the ABL policy with the BTSSCP, a “by-product” of “1:1 afforestation” (i.e., one mu of retired farmland must be accompanied by one mu of afforestation under ABL) is required by the BTSSCP. This means that new ABL area can exceed retired farmland but cannot be less than it. Moreover, our sample shows that some counties may have based payment calculation on ABL-afforestation. We believe that dropping these cases would be arbitrary and unnecessary before further information is available. To measure the effect the BTSSCP, we therefore control for household afforestation under ABL as well as 5 county dummy variables in the estimations.

The analysis uses a semi-log specification (logarithm of the dependent variable). The explanatory variables identified to be predictors of income include the two program-related variables PROGRAM and NRFL, the per capita-based side-policy variable "ABL", and four other categories of variables: 1) household production inputs or activities, including number of labors available in a household (HHLABOR), per capita farmland (LAND), per capita production investment (INVEST) (which is added gradually because of its possible endogeneity); 2) household demographics, including household size (HHSIZE) and education achievement of household head (EDUC), which is added gradually because of its possible endogeneity. EDUC is categorized into four levels, illiteracy, elementary school, middle school, and high school; and 3) dummy variables for year and province (We add county dummies for some estimations); and 4) natural and economic conditions, including annual precipitation (PRECIP), squared precipitation (PRECIP_SQ), and agricultural price index (AGINDEX) observed at the county level, poverty rate (POVERTY) and average yield (YIELD) reported at the village level. Explanatory variables in the first three categories are from disaggregated household survey, whereas the last category variables are based on aggregated data from the county and village sample. To be consistent with the scale of the dependent variables, we scale certain explanatory variables (NRFL, LAND, ABL, and INVEST) to per capita base.

4. RESULTS

4.1 Impact of the BTSSCP on income

Program intensity

We first look at the impact of program participation intensity on household income using robust OLS and FE estimations. Our intensity indicator is the area of new set-aside farmland added annually to the program. As Table 4 reports, impact of NRFL ranges from 0.01 to 0.05 with FE estimations consistently yielding estimated coefficients around 0.01. This implies that per capita household income on average increases by about 1% for each addition mu of new set-aside farmland. Because FE estimations control for the unobserved household factors, we focus on reporting results from the three FE models (FE, robust FE, and FE-AR(1)). Household size has a significant and negative impact on household income by about 22%-27%. Farmland negatively and significantly affect household income by about 3%, which may be explained by the fact that land productivity is generally low in our study region and that households hold more land do not necessarily earn more income.

Program participation

In investigating the income effect of program participation (Participation=1), we use both FE and 2SLS estimations to control for unobserved household factors. Estimated results with various function specifications are reported in Table 5. Although our IV candidate VILLINTRO passes the significance test in the first-stage regressions of IV estimations (as shown in Table 6), there are at least two reasons to dislike results from IV estimations: First, Hausman specification test suggests that IV estimation may be inferior to OLS as the latter is consistent and more efficient. Second, we feel uneasy about the high coefficients for program participation variable (ranging from 0.77 to 0.87) estimated from the IV models when counties are controlled for. When counties are not controlled for, the estimated coefficients for program participation is not significant.

In general, three FE estimation models yield consistent estimations on the impact of program participation on household income. The FE-AR(1) model seems to performs particularly well. According to its estimation, household income on average is 9% higher when the household participates in the program. Estimated coefficients for other explanatory variables are consistent with the results from the FE-AR(1) model (with NRFL as an explanatory variable) in Table 4. As expected, county-level precipitation has a positive and significant impact on household income, whereas squared precipitation as an indicator for natural shock imposes a negative influence on household income.

At last, we explore the impact of timing of program introduction at the village level on household income. As Table 7 shows, three FE models consistently estimate a significant and positive relationship ranging from 0.17 to 0.19 between VILLINTRO and household income level. This implies that household income tends to be about 18% higher if its belonged village introduces the program one year later. The result may arguably suggest two possibilities: 1) the poor households might have chosen to take advantage of the program benefit sooner than households that are less economically pressured, or 2) the program may have disproportionately targeted or favored the poor.

4.2 Household activity choice

Measuring near-term income outcomes alone is not sufficient to assess the long-run impacts of the program on rural household production structure. By 2003, up to 93% of all households had adopted the program sooner or later, leaving us a very small control group of non-participating households. Therefore, we reply on graphical analysis to derive intuitively the determinants of participation (or non-participation) and the possible adaptive behavior of households induced by the farmland set-aside program.

As Figure 2 shows[6], shares of livestock income and farming income have been declining for all households in our sample without the program in presence. In contrast, shares of non-agricultural income (which includes off-farm wage income, self-employed income, and other income) and off-farm wage income show an obvious upward trend over the same period. We then graph shares of major categories of income without the program in presence for three categories of households—all households, non-participating households, and participating households. In general, the group of 10 graphs in Figure 3 together tells the following story: Non-participating households seem to earn lower shares of farming and livestock income but higher shares of off-farm wage income and overall non-agricultural income in most of the five years as compared to the participating group. By province, non-participating households in Shanxi province earn a much higher share of farming income than Hebei and IM; whereas shares of farming income for participating households are evenly distributed among the three provinces. On the other hand, non-participating households in Shanxi earn the lowest shares of income from off-farm wage, non-agricultural, and livestock sources. Participating households in IM earn the highest share of livestock income but the lowest share of self-employed income than Hebei and Shanxi. We do need to note, however, that the non-participating group has a small sample size of 13 households, which could compromise the reliability of the above implications.

Analogous to Figure 3, the group of 10 graphs in Figure 4 illustrates major categories of real income without the program in presence for the same three categories of households—all households, non-participating households, and participating

[6] We graph only years from 1998 to 2002 because the number of observations drops to very few after 2002.

households. Over the period of 1998-2002, non-participating households tend to earn less real farming income, livestock income, and self-employed income but more real income from off-farm wage and the overall non-agricultural source than the other two groups. By province, farming income and self-employed income remain lowest for the non-participating households across all three provinces. On the other hand, participating households in Hebei earn the most income from off-farm wage income, self-employed income, and overall non-agricultural income.

Next, we look at participating group after the program adoption (see Figure 5). The average share of self-employed income was much higher when the group of participants was significantly smaller during the initial year of the program (year 2000) than the following two years. The size of the participating group then grew by 3.6 times in 2002 and 5.9 times in 2003 from 2000, driving the average share down. This may imply that households who adopted the program in the first year might hold higher pre-program levels of shares of self-employed income and overall non-agricultural income. It makes good sense that households who have already engaged in non-agricultural activities (in particular, self-employment) may be more likely to adopt the program once the program is available. The share of off-farm wage income went up by about 1.7 times during 2001-2003, indicating a possible shift of labor from farming to off-farm wage sectors. In real income terms, incomes from farming, livestock, and off-farm wage actually increased over the period of 2001 to 2003 for participating households. The rising real farming income may suggest intensified farming production.

We then look at participating group for both before and after the program adoption (see Figure 6). Clearly, the share of farming income has declined considerably over the period of 1998-2003; whereas the share of off-farm wage income has shown the opposite trend and the share of self-employed income roughly remains at the same level with slight decrease. Participating households in IM hold the lowest shares of off-farm wage and self-employed income (as well as overall non-agricultural income) but the highest shares of farming and livestock income. In real income terms, only farming income shows a decreasing trend from 1998 to 2003. Over the period of 1998 to 2003, participating households an average earned a self-employed income of 560 CNY and an off-farm wage income of 965 CNY before the program. As Figure 6 shows, both non-agricultural activities increased significantly after the program adoption (from 445 CNY to 785 CNY for self-employed income and from 594 CNY to 1,508 CNY for off-farm wage income, respectively). However, off-farm wage income grew by 2.54 times from the pre-program level, significantly faster than the increase in self-employed income (only 1.76 times).

5. CONCLUSIONS

This paper used household data to assess the immediate/near-term impact of the Beijing and Tianjin Sandstorm Source Control Program on incomes of rural households in areas where the program was implemented. Central to our analysis is a unique panel survey conducted by the State Forestry Administration in 17 counties of North China covering years from 1998 to 2003. The essential feature of the program is an annual subsidy provided to participating farmers to cover costs associated with permanent retirement of farm land and the planting of saplings. Not surprisingly, we observed a strong positive relationship between program participation and household income. We then explored impact of the program on the activity choice of farm households as well as whether or not household production activities have any effect on the participation decision. In addressing the second objective, our capability to conduct sophisticated econometric analysis was limited by the small sample size of the non-participating households. We therefore adopted graphical analysis and found evidence that: First, in the absence of the program, non-participating households tend to earn lower shares of farming income and livestock income, implying that they are less pressured by land degradation. Moreover, the off-farm wage income earned by non-participating households is higher in both share (before 2002) and real income level (before 2001). This may imply that these households may have better migration information or network that enables them to engage in migration work.

Secondly, participating households tend to engage more in self-employment before participating in the program. In addition, their non-agricultural activities have increased significantly over the period of 1998 to 2003—from 445 CNY to 785 CNY for self-employed income and from 594 CNY to 1508 CNY for off-farm wage income. In the meantime, the share of farming income has declined considerably over the period of 1998-2003; whereas the share of off-farm wage income has shown the opposite trend and the share of self-employed income roughly remains at the same level with slight decrease.

Finally, both non-agricultural activities (self-employment and off-farm employment) have increased significantly after the program adoption for the participants This may suggest that 1) farmland retirement payments may have helped farm households overcome credit constraints preventing them from starting their own businesses, and 2) farmland retirement may have freed up more labor making it possible to migrate and take urban jobs. This insight here is that participating households are diversifying income away from farming to more non-agricultural activities. This movement can be seen as a government-financed “human-capital” investment that in some sense echoes the “Hartwick rule” of sustainable development.

REFERENCE

Cardy, F. (1993). "Desertification--A fresh approach." Desertification Bulletin **22**: 3-8.

China Daily (October 28, 2003). Plan set to limit desertification, www.chinadaily.com.cn.

China Internet Information Center (2004a). China to boost sandstorm control program, www.china.org.cn.

China Internet Information Center (2004b). Reflections on twenty years' desertification control, www.china.org.cn.

Ci, L. (2004). Large-scale sandstorm disasters--their causes and prevention measures, China Internet Information Center, www.china.org.cn.

Food and Agriculture Organization. (1997). Drylands development and combating desertification: Bibliographic study of experience in China. Environment and Energy Paper 15, Food and Agriculture Organization of the UN, Rome.

Freeman, H. A., B. Shiferaw, and S.M. Swinton. (2005). Asseessing the impacts of natural resource management interventions in agriculture: concepts, issues, and challenges. Natural Resource Management in Agriculture: Methods for Assessing Economic and Environmental Impacts. (Eds B. Shiferaw, H.A. Freeman and S.M. Swinton.) CAB International 2005.

Greene, W. H. (1997). Econometric Analysis, 3rd edn, Prentice Hall, Upper Saddle River, NJ.

He, S. and G. Xiao (Jan. 28, 2003). Scientists chart route of fierce sandstorms, www.chinadaily.com.cn.

Jan, G. P. (1995). Chapter 4: Environmental protection in China. Environmental Policies in the Third World: A Comparative Analysis. Dwivedi, O. P. and D. K. Vajpeyi. Westport, CT, Greenwood Press.

Liu, C. (2003). Progress report on Beijing Tianjin Sandstorm Source Control Program, China National Forestry Economics and Development Research Center, No. 18 East Street Hepingli, Beijing, 100714, P. R. China.

National Bureau of Statistics of China (2003). China Statistical Yearbook, China Statistical Press.

Pender, J. (2005). Econometric methods for measuring natural resource management impacts: theoretical issues and illustrations from Uganda. Natural Resource Management in Agriculture: Methods for Assessing Economic and Environmental Impacts. (Eds B. Shiferaw, H.A. Freeman and S.M. Swinton.) CAB International

2005.

Reuters (2002). Economist urges China to treat root of desert woes, www.chinadaily.com.cn.

Rozelle, S., J. Huang, S. A. Husain, and A. Zazueta. (2000). China, From afforestation to poverty alleviation and natural forest management, The World Bank.

Uchida, E., J. Xu, S. Rozelle. (Forthcoming). "Grain for green: cost-effectiveness and sustainability of China's conservation set-aside program." Land Economics.

Uchida, E., J. Xu, Z. Xu, and S. Rozelle. (2004). "Are the poor benefiting from China's land conservation program?" Working draft.

Wooldridge, J. M. (1999). Introductory econometrics: A modern approach, South-Western College Publishing.

World Bank (2004). PovcalNet (A poverty database and interactive computational tool), The World Bank Group.

Xu, Z., J. Xu, X. Deng, J. Huang, E. Uchida, and S. Rozelle. (2004). "Grain for green and grain: a case study of the conflict between food security and the environment in China." Working draft. Center for Chinese Agricultural Policy, Institute for Geographical Sciences and National Resource Research, Chinese Academy of Sciences, and Dept. of Agricultural and Resource Economics, University of California, Davis.

Ye, J. (Mar. 21, 2003). Storm warning, www.chinadaily.com.cn.

Zhu, Z. and T. Wang (1993). "Trends of desertification and its rehabilitation in China." Desertification Bulletin **22**: 27-30.

Table 1. Sandstorm occurrences during selected months in 2000-2004.

	March	April	May	Total
2000	3	8	5	16
2001	7	8	3	18
2002	6	6	0	12
2003	0	4	3	7
2004	7	4	4	15
Total	23	30	15	68
Average	4.6	6	3	13.6

Source: Personal communication with staffs at State Forestry Administration of China.

Table 2. Sample distribution

Province	Population county	Sample county	Village	Household
Hebei	24	5	5	53
Shanxi	13	4	4	40
Inner Mongolia	31	8	9	95
Taijin	1	0	0	0
Beijing	6	0	0	0
Total	75	17	18	188

Table 3. Per capita income summarized by category, year, and province

Per capita net income

By Year

Year	Observations	Mean	Standard Error	Min	Max
1998	124	1481.32	660.17	100	3700
1999	124	1548.55	702.77	100	3600
2000	146	1549.73	758.30	100	4126.2
2001	158	1623.01	830.56	100	5350
2002	188	2136.81	2088.17	100	26291.6
2003	187	2692.85	2438.31	365.2	26375

By Province

Province	Observations	Mean	Standard Error	Min	Max
Hebei	238	1841.65	1261.72	233	10760
Shanxi	179	1421.61	1430.04	100	16436.27
Inner Mongolia	510	2099.81	1783.47	146	26375

Per capita household production-generated income

By Year

Year	Observations	Mean	Standard Error	Min	Max
1998	124	1481.32	660.17	100	3700
1999	124	1548.55	702.77	100	3600
2000	146	1522.39	707.04	100	3705
2001	158	1559.57	782.04	100	5350
2002	188	1919.07	2010.17	54	25750
2003	187	2148.67	2202.32	200	26375

By Province

Province	Observations	Mean	Standard Error	Min	Max
Hebei	238	1687.29	1202.86	200	10700
Shanxi	179	1147.30	614.11	100	3368
Inner Mongolia	510	1960.84	1719.15	54	26375

Per capita program-generated income

By Year

Year	Observations	Mean	Standard Error	Min	Max
1998	124	0.00	0.00	0	0
1999	124	0.00	0.00	0	0
2000	146	27.33	105.49	0	698.49
2001	158	63.44	161.81	0	1102.733
2002	188	217.74	370.05	0	2264
2003	187	544.18	1170.48	0	14769.6

By Province

Province	Observations	Mean	Standard Error	Min	Max
Hebei	238	154.36	216.51	0	1269.333
Shanxi	179	274.31	1201.75	0	14769.6
Inner Mongolia	510	138.96	325.79	0	2348

Table 4. Determinants of household income—Income effect of program intensity (Per capita annual new retired farmland)

	Dependent variable: Household per capital income			
Model	Robust OLS	FE	Robust FE	FE-AR(1)
Per capita annual new retired farmland	0.0548	0.0104	0.0104	0.0143
	(0.000)	(0.296)	(0.2180)	(0.1270)
Education of household head	0.1964			
	(0.000)			
Household size	-0.0341	-0.2214	-0.2214	-0.2748
	(0.226)	(0.000)	(0.003)	(0.000)
Household labor size	0.1168	-0.0258	-0.0258	0.0056
	(0.008)	(0.602)	(0.757)	(0.931)
Per capita farmland	0.0302	-0.0261	-0.0261	-0.0350
	(0.002)	(0.004)	(0.064)	(0.002)
Per capita afforestation under ABL	0.0072	0.0028	0.0028	0.0051
	(0.464)	(0.404)	(0.710)	(0.108)
Per capita total prod. investment	0.0002	0.0001	0.0001	0.0001
	(0.007)	(0.000)	(0.113)	(0.000)
Village annual precipitation	0.0038	0.0028	0.0028	0.0021
	(0.000)	(0.000)	(0.000)	(0.011)
Village annual precipitation-sq	-0.000004	-0.000003	-0.000003	-0.000002
	(0.000)	(0.000)	(0.000)	(0.015)
Village poverty rate	0.0207	0.0264	0.0264	-0.0913
	(0.903)	(0.845)	(0.869)	(0.488)
Village annual yield	0.0010	0.0008	0.0008	0.0006
	(0.009)	(0.011)	(0.034)	(0.048)
County agricultural price index	0.5382	0.2172	0.2172	0.0845
	(0.003)	(0.102)	(0.313)	(0.679)
Instrument for program participation	None	None	None	None
F-Test	27.66	48.51	32.4	29.8
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.4317		0.8372	
Adjusted R-squared			0.7914	
Number of Observations	916	916	916	730

Notes: P-values in parentheses. All regressions include year dummies. OLS regressions include province dummies.

Table 5. Determinants of household income—Income effect of program participation choice (Participation=1)

	Dependent variable: Household per capital income								
Model	Robust OLS	Robust OLS w/ county dummies	FE	Robust FE	FE-AR(1)	Robust OLS	Robust OLS	Robust OLS w/ county dummies	Robust OLS w/ county dummies
Program participation =1	0.1106	0.1423	0.0766	0.0766	0.0894	0.3765	0.3776	0.8557	0.7738
	(0.064)	(0.015)	(0.040)	(0.130)	(0.018)	(0.287)	(0.238)	(0.000)	(0.000)
Education of household head	0.1594	0.1832					0.2020		0.2125
	(0.006)	(0.001)					(0.000)		(0.000)
Household size	-0.0357	-0.0412	-0.2203	-0.2203	-0.2722	-0.0370	-0.0477	-0.0382	-0.0477
	(0.208)	(0.110)	(0.000)	(0.004)	(0.000)	(0.203)	(0.097)	(0.178)	(0.078)
Household labor size	0.1401	0.1346	-0.0305	-0.0305	0.0045	0.1138	0.1200	0.0837	0.0933
	(0.001)	(0.000)	(0.537)	(0.708)	(0.944)	(0.012)	(0.008)	(0.043)	(0.029)
Per capita farmland	0.0382	0.0331	-0.0260	-0.0260	-0.0375	0.0386	0.0398	0.0373	0.0380
	(0.000)	(0.003)	(0.001)	(0.050)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Per capita ABL-afforestation	-0.0012	-0.0028	0.0023	0.0023	0.0047	0.0278	0.0267	0.0218	0.0218
	(0.911)	(0.817)	(0.495)	(0.765)	(0.142)	(0.000)	(0.000)	(0.000)	(0.000)
Per capita total prod. investment	0.0003	0.0003	0.0001	0.0001	0.0001				
	(0.004)	(0.003)	(0.000)	(0.119)	(0.000)				
Village annual precipitation	0.0015	0.0001	0.0028	0.0028	0.0022	0.0039	0.0037	0.0023	0.0021
	(0.215)	(0.911)	(0.000)	(0.000)	(0.008)	(0.000)	(0.000)	(0.021)	(0.028)
Village annual precipitation-sq	-0.000002	-0.0000005	-0.000003	-0.000003	-0.000002	-0.000004	-0.000004	-0.000002	-0.000002
	(0.197)	(0.698)	(0.000)	(0.000)	(0.011)	(0.001)	(0.001)	(0.056)	(0.053)
Village poverty rate	0.2372	-0.1572	0.0106	0.0106	-0.0998	0.0484	0.0807	-0.1336	-0.1330
	(0.192)	(0.464)	(0.937)	(0.948)	(0.447)	(0.774)	(0.629)	(0.553)	(0.546)
Village annual yield	0.0007	0.0012	0.0007	0.0007	0.0005	0.0010	0.0011	0.0015	0.0016
	(0.056)	(0.005)	(0.024)	(0.055)	(0.090)	(0.013)	(0.005)	(0.001)	(0.000)
County agricultural price index	0.8489	0.5868	0.2345	0.2345	0.0561	0.4131	0.4789	0.1706	0.2874
	(0.000)	(0.008)	(0.075)	(0.277)	(0.783)	(0.080)	(0.036)	(0.375)	(0.135)
Instruments for program participation	None	None	None	None	None	Timing of village introduction	Timing of village introduction	Timing of village introduction	Timing of village introduction
F-Test	21.86	19.13	48.91	30.47	30.19	28.82	30.75	34.51	31.25
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.3467	0.3884		0.8379		0.3465	0.3854	0.2789	0.3435
Number of Observations	916	916	916	916	730	916	916	916	916

Notes: P-values in parentheses. All regressions include year dummies. OLS regressions include province dummies.

Table 6. Estimated coefficients from first-stage regressions of IV analysis

Model	Dependent variable: Program participation=1			
Dependent variable	Robust OLS	Robust OLS	Robust OLS w/ county dummies	Robust OLS w/ county dummies
Timing of village program introduction	0.0994	0.0994	0.2181	0.2193
	(0.000)	(0.000)	(0.000)	(0.000)
Education of household head		0.0169		-0.0135
		(0.301)		(0.379)
Household size	0.0037	0.0028	0.0012	0.0018
	(0.713)	(0.781)	(0.900)	(0.849)
Household labor size	0.0320	0.0326	-0.0060	-0.0067
	(0.021)	(0.019)	(0.645)	(0.611)
Per capita farmland	-0.0025	-0.0024	-0.0136	-0.0137
	(0.473)	(0.490)	(0.000)	(0.000)
Per capita ABL-afforestation	0.0121	0.0120	0.0090	0.0090
	(0.000)	(0.000)	(0.000)	(0.000)
Per capita total prod. investment				
Village annual precipitation	0.0015	0.0015	0.0011	0.0011
	(0.037)	(0.040)	(0.102)	(0.097)
Village annual precipitation-sq	-0.000002	-0.000002	-0.000002	-0.000002
	(0.008)	(0.009)	(0.047)	(0.045)
Village poverty rate	-0.1156	-0.1129	-0.4371	-0.4394
	(0.063)	(0.069)	(0.000)	(0.000)
Village annual yield	-0.0001	-0.0001	0.0006	0.0006
	(0.317)	(0.340)	(0.000)	(0.000)
County agricultural price index	0.3737	0.3792	0.1164	0.1096
	(0.000)	(0.000)	(0.221)	(0.251)
F-Test	106.22	100.39	105.44	100.86
Prob > F	0.000	0.000	0.000	0.000
T-statistic on instrument	7.63	7.63	14.02	14.04
R-squared	0.6679	0.6683	0.722	0.7223
Adjusted R-squared	0.6616	0.6616	0.7152	0.7151
Number of Observations	916	916	916	916

Notes: P-values in parentheses. T-statistic tests the hypothesis that the instrument is zero.
All regressions include province dummies and year dummies.

Table 7. Determinants of household income—Income effect of timing of program introduction at village level

Model	Dependent variable: Household per capital income			
	Robust OLS	Robust OLS w/ county dummies	Robust OLS w/ county dummies	Robust OLS w/ county dummies
Timing of village program introduction	0.0374	0.1867	0.1697	0.1737
	(0.315)	(0.000)	(0.000)	(0.000)
Education of household head			0.2020	0.1914
			(0.000)	(0.000)
Household size	-0.0356	-0.0372	-0.0463	-0.0387
	(0.223)	(0.173)	(0.077)	(0.126)
Household labor size	0.1259	0.0785	0.0881	0.0849
	(0.003)	(0.049)	(0.032)	(0.034)
Per capita farmland	0.0377	0.0256	0.0274	0.0211
	(0.000)	(0.024)	(0.014)	(0.049)
Per capita afforestation under ABL	0.0324	0.0295	0.0287	0.0051
	(0.000)	(0.000)	(0.000)	(0.643)
Per capita total prod. investment				0.0002
				(0.015)
Village annual precipitation	0.0045	0.0032	0.0030	0.0025
	(0.000)	(0.000)	(0.000)	(0.002)
Village annual precipitation-sq	-0.000005	-0.000003	-0.000003	-0.000003
	(0.000)	(0.000)	(0.000)	(0.002)
Village poverty rate	0.0049	-0.5076	-0.4730	-0.4248
	(0.977)	(0.022)	(0.028)	(0.039)
Village annual yield	0.0010	0.0020	0.0020	0.0019
	(0.015)	(0.000)	(0.000)	(0.000)
County agricultural price index	0.5538	0.2702	0.3722	0.3937
	(0.003)	(0.122)	(0.032)	(0.017)
F-Test	24.47	24.96	24.82	24.32
Prob > F	0.000	0.000	0.000	0.000
R-squared	0.3401	0.3965	0.4338	0.4718
Number of Observations	916	916	916	916

Notes: P-values in parentheses. All regressions include year and province dummies.

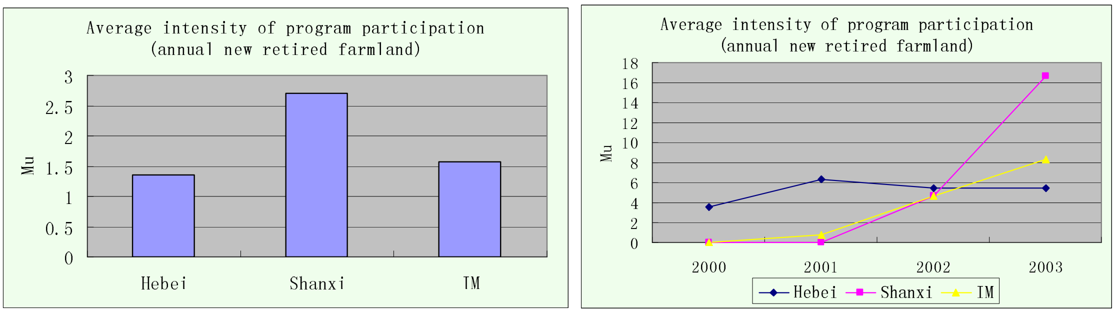

Figure 1. Average intensity of program participation (annual new retired farmland)

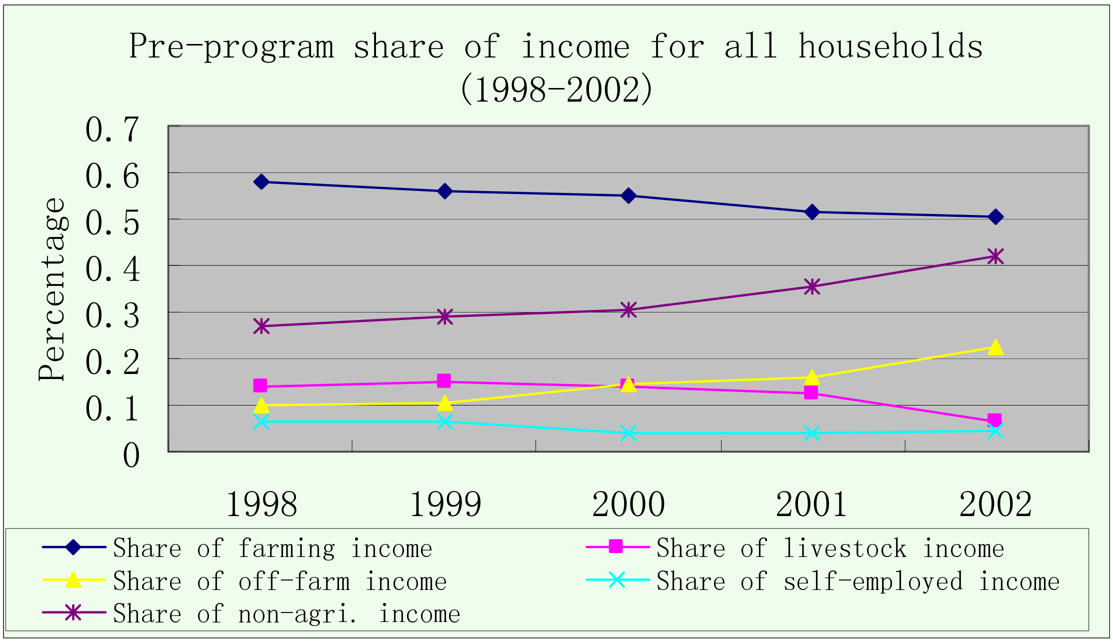

Figure 2. Pre-program share of income for all households (1998-2002)

Figure 3. Pre-program share of major categories of income for all households, non-participating households, and participating households by year and province

Figure 4. Pre-program major categories of income for all households, non-participating households, and participating households by year and province

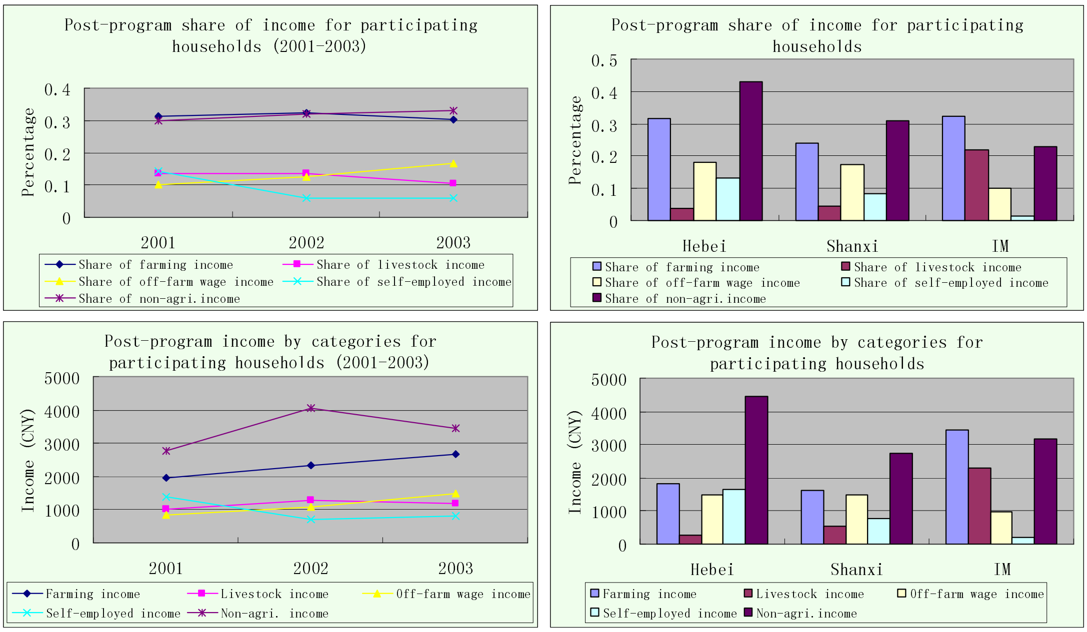

Figure 5. Post-program major categories of income/share of income for participating households by year and province

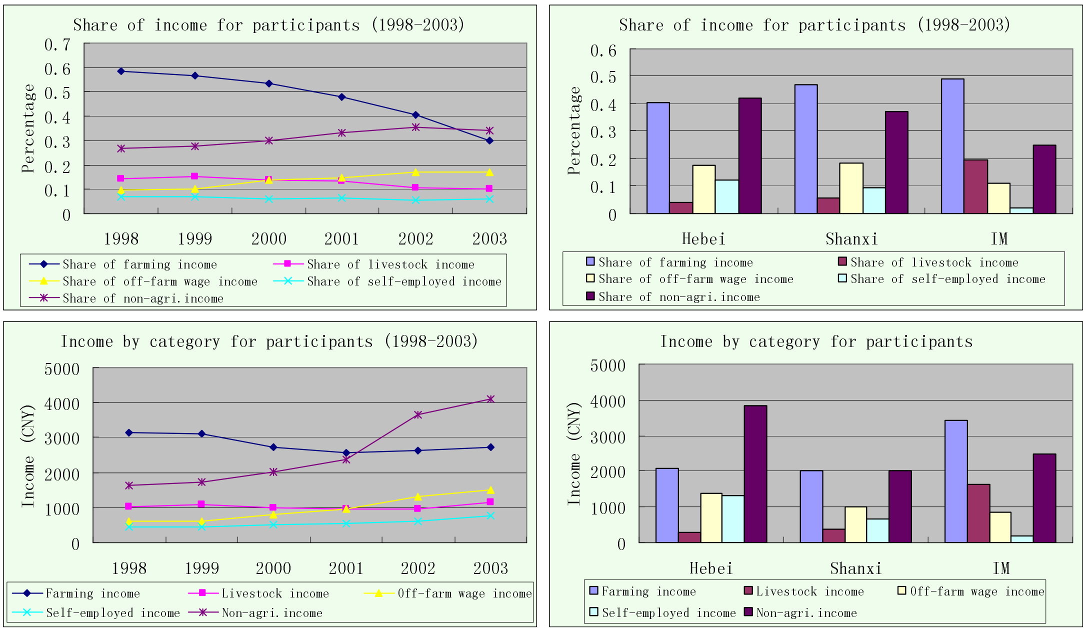

Figure 6. Major categories of income/share of major categories of income for participation households (pre-program + post-program) by year and province