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Public perception of an ecological rehabilitation project in inland river basins in northern China: Success or failure



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ABSTRACT

The need for environmental protection challenges societies to deal with difficult problems because strategies designed by scientists to protect the environment often create negative effects on impoverished local residents. We investigated the effects of China's national and regional policies related to environmental protection and rehabilitation projects in inland river basins, by studying the effect of projects in the Heihe and Shiyang river basins, in northwest China. Interviews and surveys were conducted at 30 sites in the lower reaches of these two arid basins, an area that has experienced severe ecological degradation. The survey results show the ecological rehabilitation projects adversely affected the livelihoods of 70.35% of foresters, 64.89% of farmers and 62.24% of herders in the Minqing region in the lower Shiyang River Basin; also, the projects negatively affected 51.9% of residents in the Ejina region in the lower Heihe River Basin. This caused 16.33% of foresters, 39.90% of farmers and 45.32% of herders in the Minqing region to not support the project and 37.5% of residents in the Ejina region said they will deforest and graze again after the project ends. The negative impacts of the policies connected to the projects cause these attitudes. The projects prohibit felling and grazing and require residents to give up groundwater mining; this results in a great amount of uncompensated economic loss to them. Extensive survey data document the concerns of local residents, concerns that are supported by the calculation of actual incomes. In addition, the survey results show poorer interviewees believe the projects greatly affected their livelihoods. While citizens in this region support environment protection work, the poor require considerable assistance if one expects them to support this type of work. Governmental assistance can greatly improve their living conditions, and hence encourage them to participate in and support the implementation of the projects within and outside the districts where they live.

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1. Introduction

An increasing numbers of researchers have reported that economic losses caused by environmental degradation are becoming increasingly severe; many researchers believe persistent environmental deterioration causes economic loss resulting in social upheaval and exacerbating poverty (Balmford et al., 2002). Large-scale production of consumer goods and human activities result in

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increasingly significant effects on the global ecosystem. Therefore, people pay more and more attention to the changes made to the ecosystem, and connections to human health, economics, social stability, and national security (Lubchenco, 1998; Liu et al., 2003; Lester, 2001). The concept of sustainable development has wide political, economic, and ecological implications, yet the idea is difficult to define; different regions and different races with different living conditions have different understandings related its definition. In addition, different ruling classes also think of sustainable development in different ways because they have different interests; in particular, various groups of people hold similar differences of opinion. Environmental rehabilitation is an important issue in the fragile environment of the arid regions of northwest China. Balancing the relationship between the need for

resource and economic development with the equally pressing need for environmental rehabilitation directly affects the sustainability of China's economic and social development (Science and Technology Committee of China, Chinese Academy of Engineering, 1999).

Currently, with the world's largest population, China's vast territory is experiencing rapid economic development. However, while forests cover only 16.5% of China (Liu et al., 2003) many are heavily degraded. The extent and quality of forested land is declining, especially in northwest China (National Environmental Protection Agency, 2004); for example, from 1995 to 2000 western China's forested area decreased by 891,000 hm², causing China to face greater environmental challenge than elsewhere.

Of 142 countries worldwide, China ranked 129th in an evaluation of environmental sustainability (Liu and Diamond, 2005). China's grassland area ranks second globally, behind only Australia; although 90% has been degraded. Grassland covers 40% of China, mainly in the arid north; nevertheless, China's per capita share ranks below the world average. Recently, disruption of the hydrological cycle has continually increased aridity. Deforestation and grassland degradation cause aridity; the excessive withdrawal of groundwater and the reclamation of lakes and wetlands in arid regions of northwest China have been intense, causing the spatial extent of surface water to decrease dramatically. Natural disasters cause poor harvests on about 160,000 km² of farmland in China annually.

The 1988 flood generated economic losses of 240 million USD, and stimulated the Chinese government to attempt to reduce the impact of disasters for the first time. Since the 1980s, the government has poured massive amounts of funds, manpower, and materials into projects designed to protect China's environment. An example is the "Three North" shelterbelt programme (9.6 billion USD), a wind erosion project designed to reduce the impact of sandstorms in the Beijing–Tianjin–Tangshan region (9.3 billion USD). Three North includes natural forest protection (50 billion USD) and the return of cultivated land to grassland (2.3 billion USD) or forest land (16 billion USD), etc. In addition, water and soil conservation projects and watershed construction projects were implemented in northwest China, e.g. the Heihe (total investment 400 million USD), Tarim (1.8 billion USD), and Shiyang (800 million USD) river regulation projects. Starting in 2012, the government plans to invest 787 million USD in the ten year Dunhuang Ecological Rehabilitation Project; two important objectives include ensuring water from the main channel of the Shule River flows into West Lake again and halting ecological deterioration of the West Lake Reserve. The Chinese government invested a minimum average of 8 billion USD annually in ecological rehabilitation in western China, and 30 billion USD in inland river regulation projects. These and other projects are designed to ensure the gross domestic product of the region increased by 2.6% or more annually.

A variety of comprehensive rehabilitation projects within inland river basins cover a third of China's land and affect Xinjiang, Inner Mongolia, Qinghai, and Gansu, etc. (Feng et al., 2000). The main goals include grassland protection and restoration, abandoning low-yield farmlands, planting grasses on desertified lands, establishing an environmental protection system, improving salinised and alkali soils, as well as establishing water rights and a water pricing system (Feng et al., 2012). The National Forestry Bureau and National Environmental Protection Agency jointly coordinate the implementation of watershed rehabilitation projects, organise forest protection efforts, and establish conservation areas designed to protect water sources in mountainous regions. In addition, they establish desertification control areas and nationally designated areas designed to protect public forests; the programs also relocate workers who depend on forestry and livestock

breeding or relocate foresters, farmers and herders engaged in other related tasks (National Forestry Bureau, 2007).

The National Forestry Bureau supplies seed for planting grasses and trees, establishing and protecting forests as well as conducts grassland restoration. The National Water Resource Ministry manages watershed and water resource projects while other related government departments serve as auxiliary organisations; they manage agricultural production, livestock breeding, water and soil conservation, while working to reduce poverty and conducting environmental protection work, etc. Currently, weak inter-organisational cooperation and coordination efforts are ineffective (Xu et al., 2006). For example, several rivers flow through several provinces such as the Heihe River that flows through Qinghai, Gansu and Inner Mongolia. In this case, trans-regional cooperation and coordination are essential for the successful implementation of rehabilitation projects.

By 2010, the rate of land degradation had slowed and only 20,000 hm² of cultivated lands went out of production; afforested land increased by 13,300 hm² and a total of 243,000 hm² of natural forest were protected in the Shiyang River Basin (Ma et al., 2008; Sun, 2004). The United States continues to implement similar reforestation projects with related departments providing citizens with both funding (480 USD/ha) and seeds and seedlings to restore wastelands. Funding for rehabilitation projects of inland river basins of China only provided funds to buy materials and to pay wages; no other subsidy is provided (Zhang et al., 2000).

In recent years, ecological projects in Minqin County (<http://en.wikipedia.org/wiki/Minqin>) provided subsidies such as wages for farmers; for example, funding was used to employ farmers as employees on a local desert control project (13.3 USD/person/day). Farmers participated enthusiastically while contributing to the project and received some income. The changes to the agricultural structure of the Shiyang River Basin resulted in a 68% decrease in income for the local farmers and herders. The reduced irrigation costs of the project made it widely popular but the farmers and herders earned only 71% of their previous household income. When non-agricultural job opportunities reached 20%, 25%, 30%, and 35% of total employment available in the area, the average income of individuals returned to 74%, 80%, 86% and 92% of the past income rates, respectively. Greenhouses became increasingly popular and this increased an available lump-sum subsidy of 2080 USD/hm² plus an interest-free loan of 2910 USD/hm², as a result, farmers' income returned to about 90% of their previous income (Shi et al., 2009).

However, problems remained related to the standards used for and duration of various subsidies; also, methods used to subsidise work affected the enthusiasm of local farmers and herders. Although the projects compensate farmers for the loss of income derived from growing grain because less cropland is available to farmers and herders, farmers need to know if the compensation provided for forestation activity is sustainable. Under the current conditions we do not know whether the workers will participate in the projects if compensation is not continued, or whether they will return to agriculture, grazing or deforestation activities after the project ends to ensure their source of income.

Xu Yinglong of the Chinese Academy of Agricultural Sciences believes a close relationship exists between the poverty observed in some regions and the fragile environment in those same areas. In ecologically sensitive zones, 74% of the population lives in counties with high levels of poverty, accounting for 81% of the regional population. People experiencing poverty tend to live in fragile environments; that is, these two areas (areas with poverty and those with fragile environments) have a similar geographic spatial distribution (Xu and Ju, 2009). About 600,000 people living in the inland river basins are in regions requiring ecological rehabilitation and protection; knowing how to maintain a healthy

environment while simultaneously gradually enhancing people's standard of living is an important consideration when planning ecological rehabilitation projects (Xu et al., 2003). If compensation is discontinued, this, leads the participants to return to their original sources of income and employment after a project is completed. If this leads to further environmental degradation, then their attitudes and behaviours will greatly and negatively affect the sustainability of the watershed rehabilitation project, or the sustainability of any environmental protection efforts. At present, farmers and herders can only obtain grain subsidies and small cost-of-living subsidies funded by the watershed rehabilitation project.

A survey was conducted to determine people's attitude and awareness of the rehabilitation project in the Shiyang River Basin 10 years after the project was completed (Wang et al., 2013). If the project ends in 2015 and compensation can last to 2020, 56.4% of the farmers will not give up farming; that is, they plan to return to unsustainable methods of cultivation, grazing and forestry to generate income. This inland region has a population of 5 million. Both local and financial support for the project is likely to end soon. Many research studies have documented the relationships between the economic interests of local people and natural resource protection. However, little research has addressed the complex engineering or completed a systematic assessment of the relationships between ecological protection and environmental health. That is, this type of study should include activities designed to improve the environment while considering the impact on people's livelihoods. In addition, leaders should determine if such projects provide for the long-term improvement of lives of local poor farmers and herders (Salafsky, 2011).

The research results relate not only to the problem related to these types of projects in the arid inland river basins of China but is also to the attitudes farmers and herders have toward China's other similar projects. This study will provide inspiration for ecological rehabilitation using an eco-economic approach. In addition, the policies and planning used during project implementation can provide guidelines for 150 other similar projects in developing countries. If similar projects are implemented elsewhere, those tasked with implementing them should understand the degree to which local people find the policies acceptable and

determine their attitude related to the project; otherwise attempts to implement such projects may prove futile, or reduce the project's effects.

2. Methods

2.1. The selection of study regions

Two representative regions, the Minqin Oasis and the Ejin Qi region in the lower reaches of the Shiyang and Heihe rivers, respectively, were selected for analysis. People in the Minqin Oasis depend on agricultural activities and livestock breeding (90%) or forestry (10%) for their livelihoods; those in the Ejin Qi region depend on livestock breeding in an ethnic minority area (> 90%) (Fig. 1). The two regions have experienced severe human-caused environmental degradation; as a result, they are one of China's four major dust source areas. Protecting the environment in these regions is very important to China and adjacent regions. Minqin is located in the eastern part of the Hexi Corridor of Gansu Province; it is in the downstream areas of the alluvial plain of the Shiyang River, at 1300–1400 m a.s.l in elevation. Minqin is surrounded on the east, west, and north sides by the Tengger and the Badain Jaran deserts. The arid climate has a mean annual precipitation of about 110 mm and annual evaporation exceeds 2646 mm. The environment of the Minqin Basin has been affected by human activities since the Ming and Qing dynasties (Jie et al., 2004). Since that time environmental degradation has increased, lakes have shrunk or dried up completely, natural vegetation has withered or died, and other impacts have occurred such as desertification, soil salinisation, a drop in the water table, and an increase in ground water salinity, etc. (Ding, 2007; Chang and Li, 2007). This region supports a typical, equal mix of farming and grazing. Prior to project implementation 90% the population was comprised of 30.8×10^4 farmers and herders. Grain production provides 44.3% of the region's income and the average family has 0.5–1.5 hm^2 of farmland. About 30% of income comes from livestock breeding. In 2000, the average person had 1.5 head of livestock (including cattle, donkeys, pigs, and sheep). Some of the herder families each had 50–100 sheep and several cattle. Most of the families at least had one

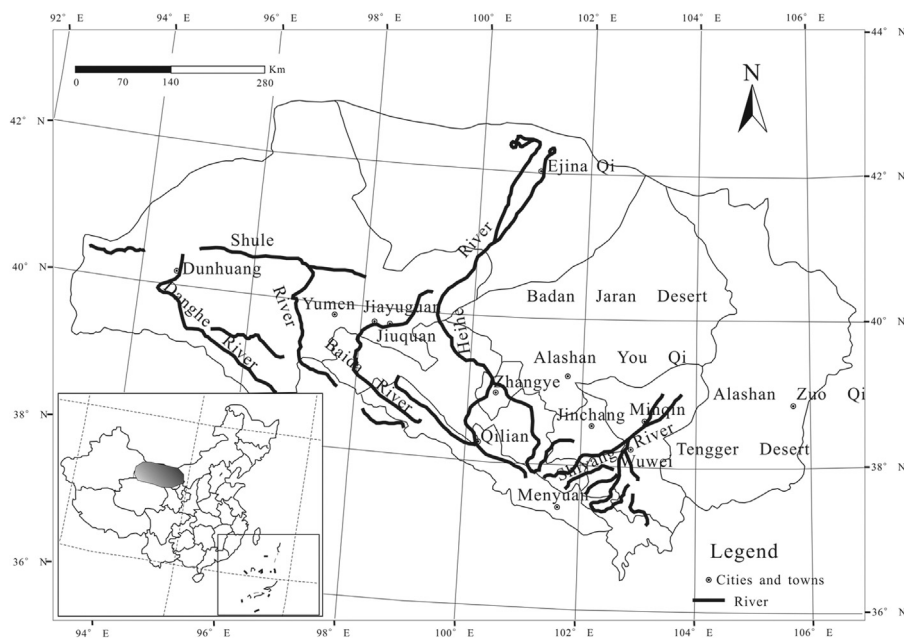


Fig. 1. Map showing the location of the study region.

head of livestock in the study region. The surveys found that farmers and herders grazed livestock on the public lands. Before implementation of the project the farmers practiced open-range grazing on government-protected lands and private plots were used to plant crops. The Forestry Bureau employs forest workers part of its national staff and workers through central or local governments. The employee manages forests and forest products, so their livelihoods are secure (SBSP, 2005).

Since 1998, the ecological rehabilitation project has affected some areas of natural forest and desert grassland in the lower reaches of the Heihe River. Fences designed to prohibit grazing, farming, and felling of trees now enclose all of the natural forest and desert grassland in the region. Most herbaceous and woody vegetation in the study region was destroyed long ago and the remaining vegetation continues to be affected by human activities. These activities include timber harvest, overgrazing, planting single species tree plantations, and planting crops that resulted in ecological degradation, and a decrease in the cover of natural and artificial vegetation. However some natural forests and artificially established forests remain.

This project prioritises the erection of fences in the areas where soil erosion is occurring to protect existing vegetation. It also includes returning farmland to grassland in desertified areas and adopting biological engineering measures to restore xerophilous vegetation. Large areas of natural vegetation in part of the region have been lost to cultivation, a lack of appropriate soil conservation, and excessive ground water withdrawal. Ecological rehabilitation of the forest and grassland area in the Heihe River delta has increased vegetation cover by 31.11 km² from 2000 to 2003. In addition, 23.42 km² of desert riparian forest and re-established forest, 3.47 km² of artificial grassland, 2.86 km² of Gobi forestland and 1.36 km² of ecological rehabilitation areas have been restored or re-established, accounting for 7.97% of the region's grassland area. The downstream basin supports the only area of natural *Populus euphratica* and *Elaeagnus angustifolia* forests in the region. Since 1987, the extent of natural forestland has decreased from 424.37 km² to present 390.28 km², or 6.35% annually.

2.2. Survey and analysis

A “person's livelihood” includes the goals, activities, and assets of a resident, including all aspects of a person's income and lifestyle (Cao et al., 2009a). This abstract idea is difficult to understand

and quantify. It deals with how someone judges the effects of an ecological rehabilitation and protection project on the project region (in this case, in the inland river basins), in light of the opinions of local people on the implementation of the project. This includes the degree to which the project affects a person's standard of living, the degree of support a person has for the project, and the anticipated future behaviour of that person after the project is complete. Therefore, evaluating a person's attitude to the project is more important than discussing the definition (Cao et al., 2009a). This study is mainly devoted to the survey and analysis of people's responses to questions about the project in the project region. The survey includes the effects of the project on the livelihood of farmers, herders, and foresters. Furthermore, data were collected related to the resident's incomes as well as their degree of support and their attitudes toward the project. The data were then subjected to statistical analysis. We analysed the views of rural residents toward ecological rehabilitation and discussed its effects on their livelihoods. Our purpose is to elucidate the relationship between the inland basin rehabilitation policies and degree of satisfaction the people felt as well as to analyse its effects on improving the local environmental and reducing poverty. We used a questionnaire to survey the residents and analysed their responses and attitudes toward the project, the survey content as Table 1, and the detail survey method is shown in references Wang et al. (2013).

The surveys were conducted in Minqin, a region mainly inhabited by the Han ethnic group, in the lower reaches of the Shiyang River and in Ejin Qi in the Heihe River Basin. About 23% of the people of the Ejin Qi region are of Mongolian descent. The research was carried out using questionnaires administered as personal interviews in May and October 2010. One adult (> 18 years old) from each household was interviewed in his or her residence. Stratified sampling, based on spatial distribution and the different aspects of project implementation, was used to ensure proportional representation of households in the regions. A total of 1900 households were randomly selected from the Shiyang river basin and 520 households from Heihe river basin.

In the Shiyang River Basin 580 people who had been engaged in forestry work before the project was implemented were surveyed along with 680 people previously engaged in agriculture or farming in adjacent areas and 680 people previously engaged in grazing activity in the project region for a total of 1940 people surveyed. The sparse population of the Ejin Qi region in the lower

Table 1

The conceptual frameworks of questionnaire items of the watershed ecological rehabilitation project (Survey: Forester, Farmer, Herder).

Survey content	Response ratio (%)	Survey content	Response ratio (%)
Shiyang River Basin			
The project affects income?	Yes, No, Unknown	The project affects the environment?	Yes, No, Unknown
Support the project?		Is environment project significant?	
Environment degradation affects health?		The project yielded effect?	
Which one is most important?	Economy, Environment, Equal, Unknown		
Heihe River Basin			
Effect on livelihood	Yes, No, Unknown	Water-saving effect	Satisfactory, Acceptable, Dissatisfactory
Results in labour surplus		Water management	
Compensated for loss from returning farmland to forest		Water price	
Given subsidy promptly		Current condition of the canal	
Deforestation after completing the project		Awareness of residents to governmental assistance	Development of water conservation industry, Returning cultivated land to forestland, support animal enterprises, Support an orchard economy, Support cultivation of vegetables

Table 2
Survey samples in the Ejin Qi region in the lower reaches of the Heihe River.

Characteristics	Group	Profession			Total (Share of the total, %)
		Farmer	Herder	Forester	
Sex	Man	190	80	50	320 (61.5)
	Woman	65	70	65	200 (38.5)
Age	20–35	105	65	45	215 (41.3)
	36–50	90	50	70	210 (40.4)
	50–65	60	35	0	95 (18.3)
	65+	65	45	15	125 (24.0)
Education level	Primary school or below	140	65	35	240 (46.2)
	Junior middle school	50	40	65	155 (29.8)
	Senior middle school or above				

reaches of the Heihe River includes 28,000 people. Of these, 115 persons engaged in forestry, 255 farmers and 150 herders were surveyed, representing groups accounting for 22.1%, 49.0%, and 28.9% of the total population, respectively. Table 2 illustrates this and shows a total of 520 people were surveyed. Efforts were made to ensure the sample included a reasonable group of forestry workers from the staff of forestry departments; these people included individuals that represented the three groups (persons formerly employed in forestry, farming, and herding).

A separate face-to-face survey was used to improve the efficiency and reliability of the questionnaire survey and to avoid interventions from external officials. A questionnaire with both fixed-response and open-ended questions was used. The fixed-response questions and the possible alternative answers were read to the interviewees and the answers recorded. The open-ended

questions were subsequently asked to and the answers taken down. The purpose of this qualitative data was to gain an in-depth understanding of the respondents answers. The survey was pre-tested the survey to identify and correct any problem relative to how the questions were phrased. The survey was then revised, as needed, to resolve these problems (Wang et al., 2013).

Problems uncovered during the survey were mainly related to the degree of satisfaction the respondents had with the implementation of the project (i.e. the effect of the project on their livelihood) and the differences in their incomes. While the survey had a high response ratio, some people responded inappropriately; for example, some respondents provided several answers, no answer or failed to respond to one or two questions. This ratio of inappropriate responses was 8.6% for respondents from the lower reaches of the Heihe River and 10.5% for those from the lower reaches of the Shiyang River. The survey requested information related to annual per capita net income (mean annual net income of all family members collectively), age of the person surveyed, his or her level of education and gender. In the survey conducted in the Shiyang Basin each person was requested to answer the following questions: Which is more important, environment protection or economic development? Does environmental and ecological degradation improve or negatively affect their health? Is comprehensive environmental rehabilitation in a basin valuable? Do the prohibitions against felling and grazing adopted in the region of the project affect their annual income and way-of-life (i.e., that is, can they feed themselves and their family)? Do they support the project? Do they believe the project has reached the expected target (Table 5)? The main survey content in the lower reaches of the Heihe River included questions related to social and economic factors as well as the desire for economic compensation. The herders in the Ejin Qi region were also asked whether they supported the prohibition against grazing (Tables 8 and 9).

Table 3
Timetable of ecological rehabilitation before and after implementation of the watershed rehabilitation project in the Minqin region.

	Sample number	Forester 540	Farmer 680	Herder 680	Total 1900	SD ^a	P
Mean	Before implementing forest project (day/yr)	14.78	12.99	23.09	17.11	0.452	0.001
Dam area	After implementing forest project (day/yr)	46.65	24.48	35.14	34.55	0.878	0.001
Lake area	After implementing forest project (day/yr)	50.32	28.74	39.12	38.59	0.860	0.001

^a SD, standard deviation.

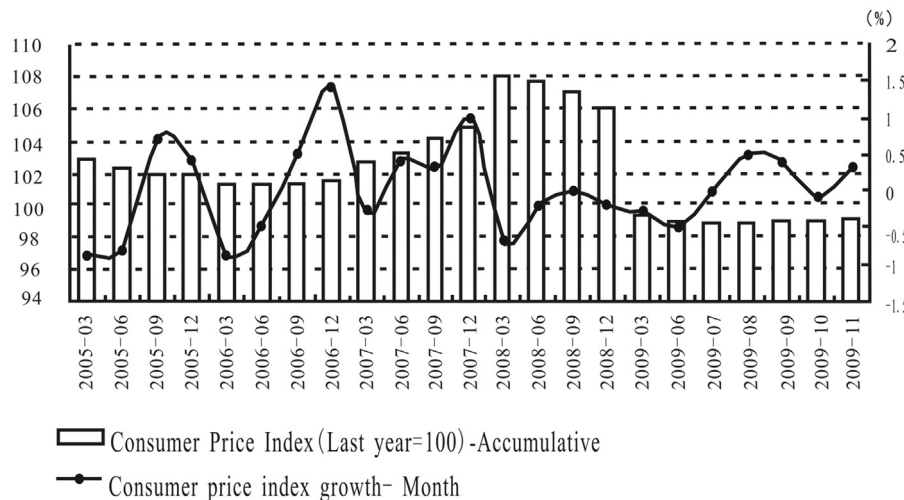


Fig. 2. Seasonal variations in the consumer price index. Data source: National Statistical Bureau of China.

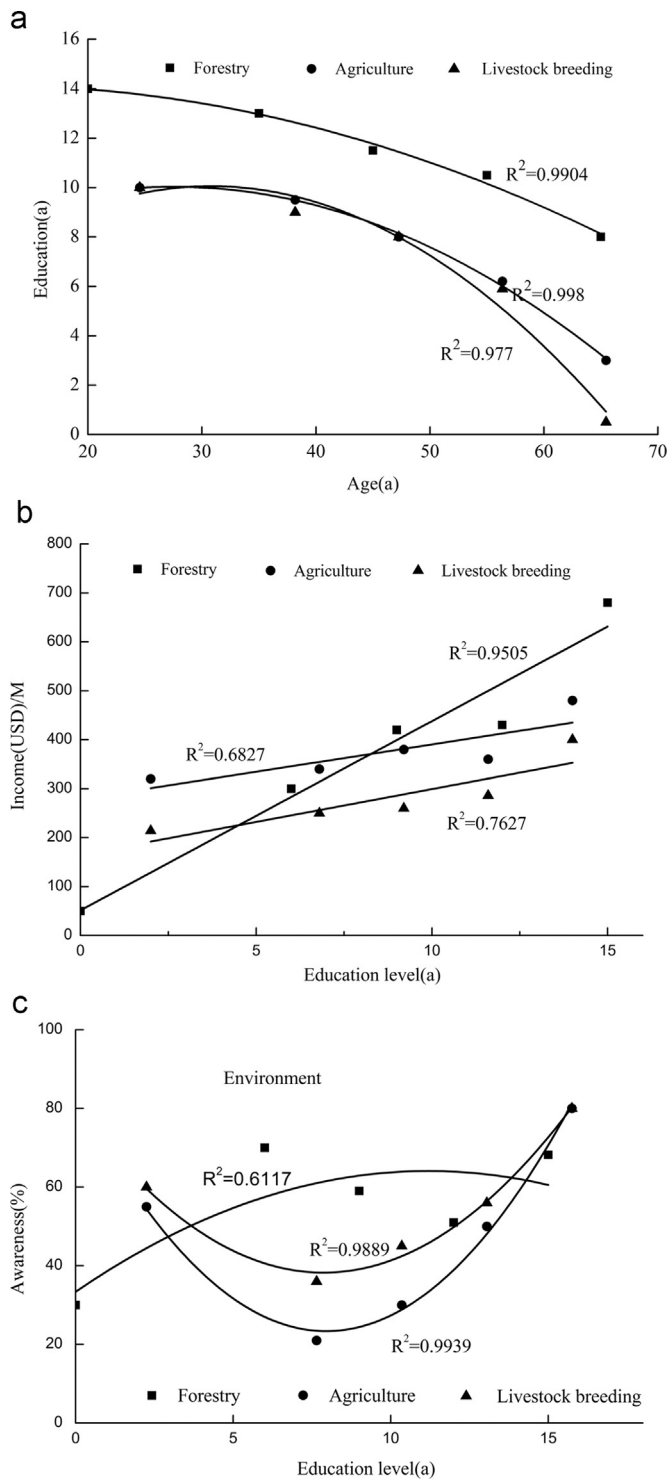


Fig. 3. (A). Correlation diagram of education level and income: total confidence at ($P < 0.001$), single confidence at ($P < 0.01-0.05$). (B) Correlation diagram of education level and age: total confidence, ($P < 0.001$); single confidence, ($P < 0.01$). (C). Correlation diagram of age and net income, (comparative study of the 65 age group, $P < 0.001$).

The government had provided compensation in the form of 500–800 USD/hm² to provide the foresters, farmers and herders with enough money to buy seed, seedlings and other materials in the effort to return cultivated land to forestland and grassland and to restore wasteland through the prohibition of grazing. The amounts provided from the compensation fund associated with the rehabilitation project were distributed based on the local

standard-of-living and could only be used by participants to buy the necessary seed and live materials; the participants were required to complete the reforestation task for the project. In the Minqin region, the participants completed the reforestation task within an average of 30.55–38.59 days without receiving a salary (Table 3) after the rehabilitation project was implemented. That is, the work had to be completed before the people received compensation. Part of compensation fund was used in this way and the government extended the compensation period to maintain the farmer's participation and interest (Zhi et al., 2004). At the end of 2000, the Ejin Qi region became the first district in China to participate in a watershed rehabilitation project, especially one that implemented a prohibition against grazing and involved the erection fences across the entire pastoral region; this led residents to abandon cultivation on a large scale. Statistical data were analysed related to economic development in Inner Mongolia and Gansu Province in recent years (2000–2010); the analysis also considered economic losses (SBSPP, 2005) and the sustainability of the ecological rehabilitation project and the environment protection services in the Ejin Qi (2000–2010) and Minqin (2006–2010) region after the project's initial implementation. The statistical data from the China Statistical Bureau for 2005–2009 shows that the stockpiling of agricultural products lessened the annual inflation rate of the consumer price index of China in 2009 (Fig. 2). These statistical data were used to regulate the income calculations that were in turn used to determine the level of funds provided to farmers and herders. The statistical data were analysed with SPSS software (SPSS Co., Chicago, Illinois, USA) and the regression analysis conducted with SPSS software was used for correlation analysis of the variables (F test, $P < 0.05$) to define the interrelationships and differences of several variables.

3. Results

3.1. The relationships between the level of education and the resident's income

Analysis of the socioeconomic survey data from the study region shows residents in Gansu Province earned an average of 580.0 USD annually. The Minqin region survey data described above includes the resident's income, level of education, age, and the ratio of men to women. Regression analysis revealed showed a positive correlation between the level of education and net annual income, which was higher for foresters ($R^2 = 0.9505$, $P < 0.01$; Fig. 3) and lower for herders and farmers ($R^2 = 0.7627$, 0.6827 , $P < 0.01$; Fig. 3). Foresters and farmers at the age of 20–30 and old men above the age of 60 had the lowest net income of all groups (Fig. 3C, $P < 0.01$). Conversely, the linear regression shows a negative correlation between the age of herders and annual net income ($R^2 = -0.6817$, $P < 0.05$; Fig. 3C); similarly, a significant negative correlation exists between the level of education and age of foresters, herders, and farmers ($R^2 = -0.990$ to -0.998 , $P < 0.001$; Fig. 3B). Men had a significantly higher net annual income level of education than women.

3.2. The effects of the project on the living standard of various people

The mean annual wage of foresters in 2000 was 1060.0 USD based on the Minqin survey data, approximately 1.3 times the mean wage of urban staff (national official staff in cities). However, the incomes of foresters and rural residents (farmers and herders) increased slowly from 2000 to 2009, while the incomes of city staff and urban residents increased three times in the same period. Therefore, 10 years after project implementation the income of foresters was only 0.8 times the income of urban staff, while the

Table 4

The situation of implementing the return of farmland to forestland in part of villages in Chongxing Township in Minqin County.

Village	Willing to give up cultivation			Not willing to give up cultivation		
	Number of families surveyed	Total area/hm ²	Returned area/hm ² /family	Number of families surveyed	Total area/hm ²	Returned area/hm ² /family
Shuangqiao	4	1.03	0.26	1	0.07	0.07
Heishan	12	1.63	0.14	12	1.61	0.14

Table 5Responses of foresters, farmers, and herders to the watershed ecological rehabilitation project in the Minqin region ($P < 0.001$).

Career of person sampled	Response ratio (%)				SD ^a
	Forester	Farmer	Herder	Total	
Number of people questioned	540	680	680	1900	
Which one is most important?					
Economy	8.3	25.50	23.54	19.91	0.736
Environment	41.56	27.53	30.35	32.54	0.583
Equal	48.04	39.14	39.87	41.93	0.387
Unknown	2.1	7.83	6.24	5.6	0.232
Environment degradation affects health?					
Yes	51.47	60.56	56.48	56.51	0.362
No	35.56	32.46	41.25	36.47	0.376
Unknown	12.97	6.98	2.27	7.0	0.426
Is environment project significant?					
Yes	66.2	59.67	33.83	52.28	1.40
No	32.51	28.31	58.56	40.33	0.95
Unknown	1.29	12.02	7.61	7.4	0.43
The project affects income?					
Yes	70.35	64.89	62.24	65.48	0.33
No	20.16	22.65	28.34	23.98	0.34
Unknown	9.49	12.46	9.42	10.53	0.144
The project affects the environment?					
Yes	79.82	34.94	36.97	48.42	1.98
No	17.31	61.47	56.16	47.02	1.88
Unknown	2.87	3.59	6.87	4.56	0.17
The project yielded effect?					
Yes	65.7	63.83	39.26	55.57	1.22
No	32.3	29.78	55.31	39.6	1.17
Unknown	2.0	6.39	5.43	4.8	0.18
Support the project?					
Yes	79.87	55.73	48.48	60.0	1.29
No	16.33	39.90	45.32	35.14	1.20
Unknown	3.8	4.37	6.2	5.43	0.12

^a SD, standard deviation.**Table 6**

Surveyed data of irrigated land and water cost for peasant households in Donghu Weijie village in the Minqin region.

Peasant household (family number)	Annual net income/USD	Irrigated land area/hm ²	Annual mean water cost/USD
6	2000–3000	1.0	300–340
7	3000–4000	0.53	200
5	2000–2300	1.17	250
4	2000–3000	0.6	340
4	2400–2600	0.53	200
2	1000–2000	0.27	800
4	3000–4000	0.53	140

income of rural residents was 0.3 times the income of urban residents (Fig. 3C). After implementing the project, 20–40% of workers engaged in forest work lost their jobs and had to seek other work because of the prohibitions against felling, cultivation and grazing, although the Forestry Bureau offered to pay their living expenses. The forestry departments provided about 300 USD/yr as unemployment compensation; this was equivalent to 28.3% (or 106 USD) of the income of foresters received before implementing the project. That is, the foresters lost 760 USD/yr in income. The surveys of farmers who gave up cultivation also demonstrated this loss of income. A total of 29 families were surveyed; 13 families (44.8%) were not willing to give up cultivation (Table 4) implying that local farmers are not willing to accept the current compensation policy for giving up cultivation.

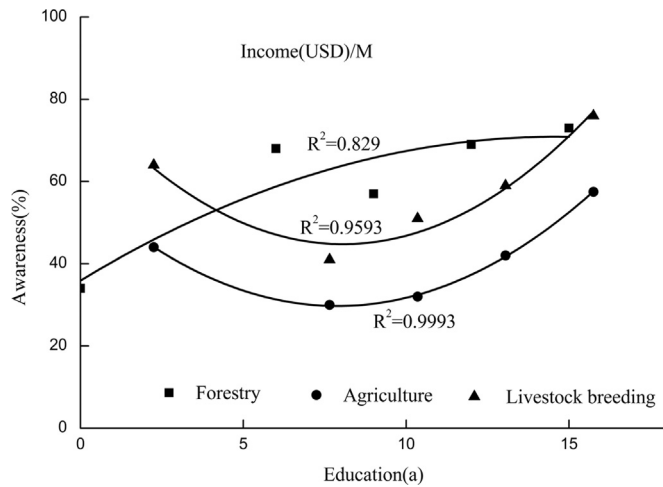
3.3. The awareness of people to the environment protection project

Of the respondents in Minqin, 56.51% have a basic awareness of the project ($P < 0.001$, Table 5), i.e. they believe the deteriorating environment, such as frequent dust storms, forest degradation, and a reduction in biodiversity, will affect their health. In addition, most respondents (41.93%) think that environmental protection and development of the economy are equally important. In addition, 32.54% and 19.91% believe that either environmental protection or economic development is more important, respectively. Although most of the people surveyed think the environment protection project is reasonable, the prohibition of felling and grazing has adversely affected the income of most residents (65.48%).

Once the project started, nomadic herders turned to corral animals; this greatly increased the expenses of the herders. Before implementing the project, herders could freely use public lands, did not need to buy fodder; with open grazing animals and herders are not restricted by fences and property rights, so open grazing requires little manpower. However, now herders must spend some money to buy fodder for the pen-fed animals. We conducted a weighted calculation of the cost to different families with different numbers of animal (emphasis is placed on the cost of labour and of feeding animals) to calculate the cost of buying fodder to feed animals and assess the effect of this cost on the livelihood of local residents. In the study region, each family has at least three head of livestock. Detailed statistical data related to the kinds and numbers of animals are complex, and reliable data are lacking. In addition, some livestock are grazed on collectively owned lands. For this reason, we conducted an integrated analysis of all residents in the calculations including the cost used for feeding three animals and the mean values for everyone and for each family. Based on this method, each person spends an average of more than over 36 USD/yr to buy fresh grass, the equivalent of 6.6% of the per capita net income of local farmers (Table 6). Compared to open range grazing on public lands prior to project implementation, this represents an important loss of income to the herders. This type of uncompensated loss affected about 600,000 rural residents creating an annual loss of 21.6 million USD in the inland river basin. This may be why local farmers and herders have different attitudes related to the project: 60.0% of

Table 7Correlation coefficients (R^2) of income (USD) variations of farmers and their awareness to the project significance in the Minqin region.

Trade	Other factors							
	Environment	Health	Significant	Life	Support	Effective	Improved	Time
Forestry	0.6757	0.982	0.3616	-0.4087	0.4094	0.4163	-0.5584	-0.7608
Farming	0.4262	0.5871	0.8319	-0.4698	0.7966	0.3564	-0.4471	-0.8755
Grazing	0.5669	0.3645	0.5178	-0.3319	0.5379	0.3791	0.4328	0.1495

**Fig. 4.** Awareness of farmers and herders of the effects of the environment and income, based on education level.

residents did not support the project, 65.48% thought that the project affected their income, and 40.33% thought that the project was had insignificant effects on improving the landscape (Table 5).

3.3.1. Evaluation of the effect of the project on net income

Because net annual income averaged 4199 USD (based on a family with three members), the majority of the respondents think the project and economic development are equally important increased, and the majority of the respondents also think the degraded environment affects their health, the so believe the project is reasonable and has yielded some positive results. Therefore, the majority of the respondents support the project. The net income of local people was significantly positively correlated with the types of answers to the questionnaire listed above; that is, those who thought the project was reasonable had higher incomes ($R^2 = 0.84 - 0.99$, $P < 0.01 - 0.001$, Table 7). After project implementation, the ratio of those who earn a high income to those who support the project decreased (Table 7). Conversely, people felt the project had a negative impact on their income and their lives whether or not their income increased or not, ($R^2 = 0.3319 - 0.4087$, $P < 0.001$, Table 7). Similarly, a significant negative correlation exists between income and the numbers of foresters and farmers who believed the project needs to be improved and the time taken for them to plant trees and grasses ($R^2 = -0.7608$ and -0.8755 , respectively, Table 7).

3.3.2. The relationship between education and awareness of the environmental protection project

As people became more educated, from illiteracy (0 yr) to university educated (15 yr), more of the respondents felt environmental improvement and economic development are equally important. Similarly, the viewpoints that (1) environmental degradation severely affects their health and (2) the project is reasonable (4 yr) were positively correlated with the level of education ($R^2 = 0.6117 - 0.9939$, $P < 0.001$). Conversely, with the

exception of herders, those who spent less time planting trees every year, had a stronger negative correlation to their level of education ($R^2 = -0.7608$ to -0.875 , $P < 0.001$, Table 7). The ratio of the respondents that think their income and living standards are adversely affected by the project first increased and then decreased when compared to the level of education (Fig. 4).

3.3.3. Awareness of people of different age groups to the project

The surveys showed as farmers and herders became older (ages of 20–45) the number who think the environment is important decreased, but then increased significantly for those above 45 years old ($R^2 = 0.8497 - 0.9073$, $P < 0.001$, Fig. 5A). However, the awareness of foresters showed a reverse trend, i.e. increasing at first with age and then significantly decreasing ($R^2 = 0.8497 - 0.9073$, $P < 0.001$, Fig. 5A). The percentage of people who think the project adversely affected their standard of living and the time used to plant trees and grasses increased, and the time spent by herders and farmers first increased but decreased for those above the age of 45. In contrast, the awareness of foresters first decreased but later increased for those above 45 years old (Fig. 5B, D). However, as residents aged their awareness of the effects of the project on their health declined (Fig. 5C), showing that local residents have a low standard of living. They live in a poverty-stricken region, most work hard for a living and pay little attention to their health.

3.4. Effect of the project in the lower reaches of the Heihe river

The ecological rehabilitation project improved environmental conditions, but negatively affected the livelihood of local residents. The survey results (Table 8) show 51.9% of peasant households think that the project affects their livelihood negatively; 50% believe they were not adequately compensated for giving up cultivation and grazing with the establishment of public forest. Therefore, 37.5% of people plan to definitely graze animals again when the compensation policy ends even though grazing is unsustainable (Table 8); therefore, the sustainability of the project remains in question.

About 65.3% of peasant households in the lower Heihe River basin generally accepted the current water-saving efforts, but 34.7% of farmers believe the project did not to provide expected results (Table 9). The farmers generally accepted the water management system (65.3%) and the price of water (71.4%), but many people were not satisfied with the canal engineering (62.2%, Table 9). They believe the poorly designed canals did not adequately consider local topography making irrigation difficult. They believe the canals need to be reconstructed, because poor management resulted in part of main canal being destroyed because it is useless. After implementation of the water transfer and rehabilitation protects, local government readjusted the regional agricultural planting structure. Farmers in Ejin Qi mainly plant cotton and cantaloupe. Some farmers constructed drip irrigation systems with good results; demonstration plots were established but drip irrigation has not yet become widely accepted.

In the lower Heihe River Basin the people hope the government will support the following project concepts: development of a

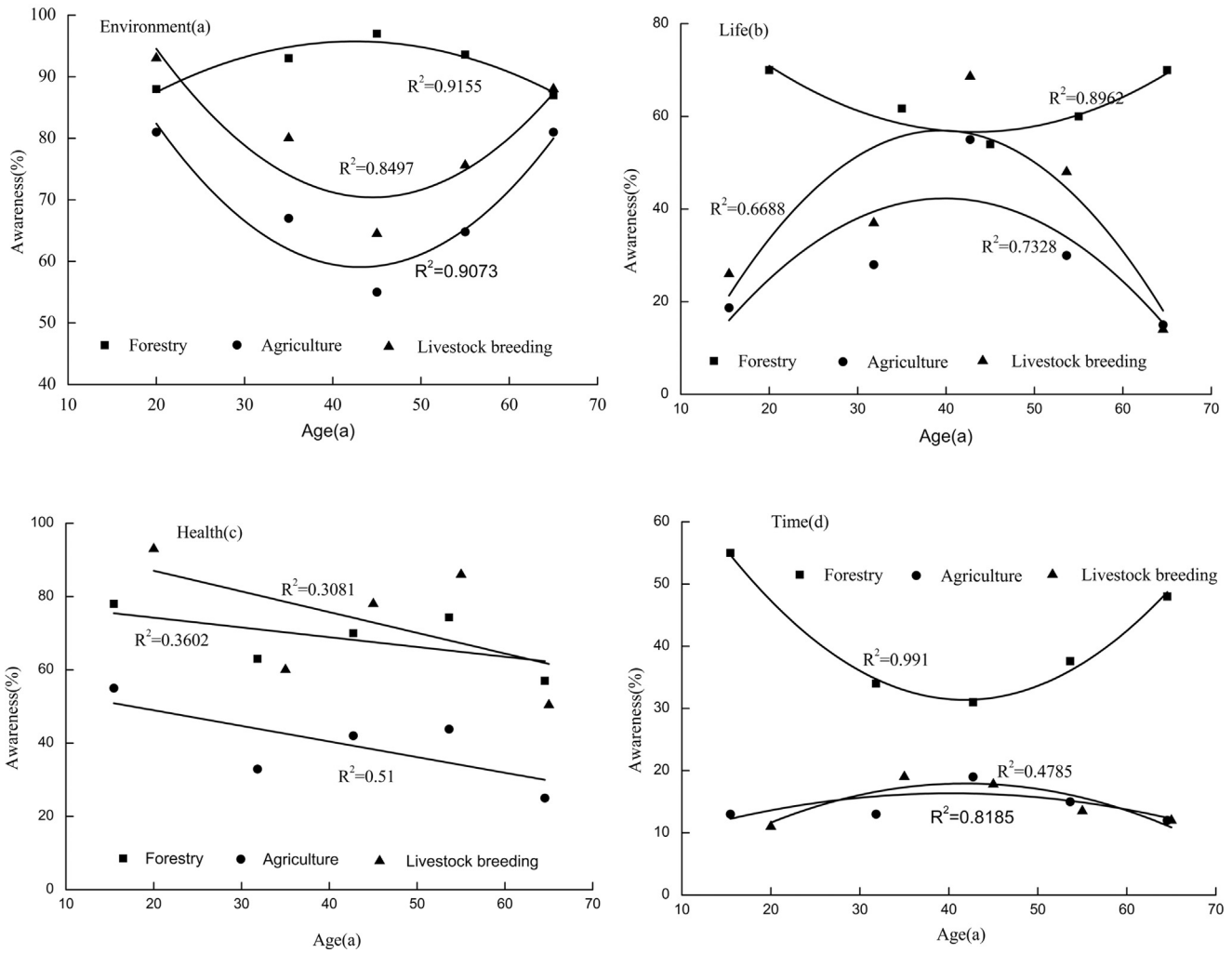


Fig. 5. Awareness of people of different age groups of the environment protection project in Minqin region. a: awareness of the environment; b: awareness of life; c: health; and d: time.

Table 8

Awareness of farmers about the effects of the ecological water transfer project from the Heihe River and the ecological rehabilitation project on their livelihood.

Respond Response	Yes (%)	No (%)	Unknown (%)
Effect on livelihood	51.9	42.3	5.8
Results in labour surplus	43.3	46.2	10.6
Compensated for loss from returning farmland to forest	47.1	50.0	2.9
Given subsidy promptly	70.2	26.0	3.8
Deforestation after completing the project	37.5	54.8	7.7

Table 9

Awareness of farmers to the effect of water resource use in the lower Heihe River Basin.

	Satisfactory (%)	Acceptable (%)	Dissatisfactory (%)
Water-saving effect	12.2	53.18	34.7
Water management	13.3	65.3	21.4
Water price	12.2	71.4	16.3
Current condition of the canal	10.2	27.6	62.2

water conservation industry, 45.9%; the return of cultivated land to forestland, 29.8%; animal husbandry, 11.0%; an orchard economy, 8.1%, and; vegetable planting (5.2%; Fig. 6). This showed that

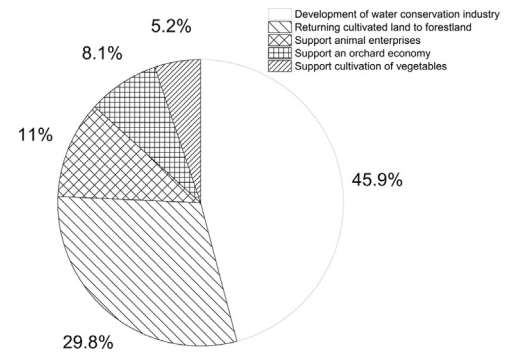


Fig. 6. Awareness of residents of the ratio of governmental assistance in the lower Heihe River Basin.

farmers and herders in the region clearly understand the water shortage problem; they hope the government will intervene and preferentially support effective water conservation efforts for industry.

4. Discussion and conclusion

In these projects in inland river basins, national and local governments shared the cost of watershed rehabilitation equally.

Before 2000, the governments requested farmers and herders to spend an average of 17.1 d/yr voluntarily planting trees near their homes. After project implementation in 2000, farmers and herders in the Minqin region averaged 34–39 days spent each year planting trees without compensation (Table 3); now they can be compensated by the government for returning farmland and pasture to forest land, such as an annual subsidy of 500–800 USD/hm². The local economic system that had been based on forest resources and livestock breeding was severely negatively impacted by the prohibition of farming, felling, and grazing in this poverty-stricken area. The combination of local governmental responsibility and rights is a sensitive problem in China and the method of administration used here, although it is a commonly used technique, often yields results that are completely opposite of the intended goal (Xu et al., 2006). More highly skilled forestry workers can be employed to implement the project, but other unskilled workers remain unemployed and helpless. Their lives are easily affected because most are older and poorly educated. From 2001 to 2004, 23.5% of former forest workers lost their jobs. A recent investigation shows the average person lost income of 760 USD/yr because of the effects of the ecological rehabilitation project in the inland river basin. Therefore, surveys, including ours, show that although the project produced significant and necessary results in saving China's forests and improving the environment, residents in the region rapidly fall into poverty (Cao et al., 2009b).

This study shows these respondents with lower incomes have a fragile livelihood. They received little or no compensation for their losses and they were adversely affected by the project. Some residents in the poorest village believe the project severely damaged their livelihood, because they failed to receive any vocational training from the government and lack alternative job opportunities. Well-educated people can use their skills to seek jobs in cities (Cao et al., 2009b). The studied results indicate that a lack of education made young people (20–29 years old), old people (> 60 years old) and women the most economically susceptible. Therefore, the youngest and oldest residents along with women believe the project adversely affected standard of living; so few support the project. The most susceptible residents became even poorer, because they had little vocational training, few job opportunities, and failed to receive financial aid (Yang, 2004; Yang et al., 2005).

During implementation of this particular ecological rehabilitation project in an inland river basin, the success of the project will be problematic if project managers make no effective effort to prevent long-term poverty of local farmers and to understand their attitudes, views, and the degree of support for the project. The surveyed results showed that 37.5% of farmers, herders and foresters in the lower Heihe River basin planned to return to their former lands and unsustainable methods of making a living. In fact, the project changed land use patterns and caused conflicts related to foods, living materials and income of local people; this severely affects the ability of the project to reach its expected target of sustainability (Brockington et al., 2006). Planners should provide adequate funding and materials to compensate all residents negatively affected by the project to ensure its smooth implementation; this especially applies to poorly educated residents and older men and women. This compensation should include technical and monetary assistance, used to pay local residents to participate in the project and ensure the project realises its primary target while increasing the income of local residents. Providing education for rural residents is particularly important; furthermore, the government should fund health and retirement insurance for the residents (Cao et al., 2009c). A suitable compensation system and favourable policy can be used to improve the standard of living of local residents while promoting local economic development; only through the combined use of environment protection and economic development can the natural

environment be effectively improved while ensuring sustainable development.

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