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# Coupling Relationship Analysis on Households′ Production Behaviors and Their Influencing Factors in Nature Reserves: A Structural Equation Model

WANG Changhai, WEN Yali, DUAN Wei, HAN Feng

(*School of Economics and Management*, *Beijing Forestry University*, *Beijing* 100083, *China*)

**Abstract:** A households′ production behavior directly influences the quality of the environment and determines the successful development of nature reserves. Meanwhile, the households′ production behaviors are complicated by interrelated factors, such as protection attitudes, resource endowment, and family wealth. This research evaluated households near the Crested Ibis National Nature Reserve in Shaanxi Province, acquiring data from 436 households around Yang County and Ningshan County in the south slope of Qinling Mountains, China. Based on the collected data, we developed a structural equation model to evaluate the coupling relationships among households' protection attitudes, production behaviors, resource endowment, and family wealth. The results showed that: 1) households with great resource endowment had more negative attitudes, probably due to their greater protection costs; 2) the households with higher education levels had worse protection attitudes; 3) the households with more family wealth were likely to use fewer fertilizers, pesticides, and firewood; 4) the households with more resource endowment showed less production and management behaviors; 5) the enhancement of households′ attitudes improved production behaviors to protection the environment, but the effects were not statistically significant. Our results provide a basis for the government′s protection policy making, exploring the effective management measures that are beneficial for both nature reserve management and community development.

**Keywords:** family wealth; protection attitudes; production behaviors; resource endowment; structural equation model; Crested Ibis National Nature Reserve

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## 1 Introduction

Global biodiversity has declined sharply, with the increasing human population and rapid development of society and economy. This reduced biodiversity may not only cause the distinction of species and genes, but may also threaten the ecological safety of a country or a region (Allendorf, 2007; Spiteri and Nepal, 2008). Protected areas are the last refuges of the world′s extant biological wealth; these areas play a key role in conserving biodiversity (Muller and Kollmair, 2000; Werver and Lawton, 2008; Nepal and Spiteri, 2011; Wang *et al*., 2011). However, 70% of the world′s protected areas are inhabited by subsistence-based human populations, and many others are being threatened by encroachment (Kideghesho *et al*., 2007; Khadka and Nepal, 2010). As a result, there are increasing conflicts between protected areas and local communities in many aspects,

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Corresponding author: WEN Yali. E-mail: wenyali2003@163.com

for example, the contradiction between resources utilization and protection, the clashes of land-ownership, civilization and policy. Such conflicts are one of the most intractable problems in biodiversity protection (Galvin *et al*., 2006; Wang *et al*., 2010a; Wang *et al*., 2010b). Guaranteeing human survival while protecting biodiversity has become an important global issue (Nautiyal, 2011).

As the main body of biodiversity protection, the farmer households around protected areas are the users and protection executors of biodiversity resources (Karamidehkordi, 2010; Nepal and Spiteri, 2011). Their agricultural production behavior constitutes a key factor determining the effects of biodiversity protection and plays an important role in biodiversity protection. Learning about the protection attitude of farmer households has widely attracted researchers, protection institutions, and authorities because household protection attitude is considered a key factor in the successful development of protected areas (Ambasthak *et al*., 2007; Kideghesho *et al*., 2007; Lee *et al*., 2009; Nepal and Spiteri, 2011). Protection attitude is widely used to evaluate whether the household understands the protection measures and accepts the implementation of protection projects (Holmes, 2003; Mcclanahan *et al*., 2005; Kaltenborn *et al*., 2012). Many studies have indicated that due to the strong correlation of households' protection attitude with households' actual behaviors, protection attitude can be used to predict households' production behavior, cognition, and reaction to protection behavior (Rishi, 2007; Tessema *et al*., 2010; Tesfaye, *et al*., 2012). The active attitude of the household can enhance the protection aim, and vice versa. Therefore, it is essential to learn the households' protection attitude for successful local community management and protection of natural resources.

According to previous studies, the household production behavior is influenced by many factors, including social psychology theories, personal characteristics, and external environment factors (Harper *et al*., 1990; Holloway and Ilvery, 1996; Willock *et al*., 1999; Cherchye *et al*., 2011; Wang and Yang, 2011). Scholars often adopt logit model or probit model to analyze certain sustainable agricultural production measures and technology adoption (a binary variable). Generally, four dependent variables are introduced in the model: 1) household characteristics (e.g., age of decision-maker, education of decision-maker, family size, and decision-maker cognition in the environment); 2) farm characteristics (e.g., farm scale, planting area, farmland segmentation condition, plot slope, and the temperature and moisture level of soil); 3) economy and management characteristics (e.g., income, risk preference, loan, and agricultural mechanical equipment); 4) exogenous factors (e.g., agricultural information acquisition, agricultural technology extension, agricultural systematic production, and household social relationship). Employing multiple linear regression analysis, Okoye (1998) conducted a comparative analysis of the measures adopted by 125 households in controlling soil erosion in Nigeria and found that income, farmland area, and risk attitude were the most important factors influencing the adoption of measures; however non-farming employment, farm production price, and the interest rate affected the adoption of traditional measures. Willock *et al*. (1999) measured household attitudes goals/objectives and behaviors and used them to construct psychometric scales of measurement. This theory was extended by Austin *et al*. (2001), who suggested that personality and intelligence also substantially influenced household behavior. Arellanes and Lee (2003) analyzed the household adoption of Labaranza Minima technology and green manure technology in households in Honduras by using a logit model; they found that the adoption of the technologies was mainly affected by plot characteristics (e.g., plot ownership, plot slope, and household perception of plot quality). Knowler and Bradshaw (2007) confirmed 170 significant variables and identified that a few of them have wide application by reviewing 31 studies about household adoption of agricultural conservation measures. Chen and Ma (2007) studied the households' willingness to reduce the use of nitrogen fertilizer in food crops in Shandong Province, China. His results showed that apart from basic variables such as household income and agricultural labor education, the influential factors also included other variables such as the households' awareness of fertilizer overuse and pollution, the acceptance of fertilization guidance by the agricultural extension station, application of organic fertilizers, and the households' attitude towards risk. Hou (2012) analyzed the current status of agricultural production and the underlying factors affecting such production by using the household survey data for Wuhan City, Hubei Province, China. His results revealed the dynamic process of households′ production behavior.

Because household agricultural production behavior is affected by a number of factors and the relationships among these factors are complicated, it is difficult for logit or probit models to recognize the coupling relations among these factors. Therefore, the results from the models may be misleading in guiding household production behavior. Thus for, most literature has only addressed households′ willingness for sustainable agricultural production, paying little attention to the awareness and practice stages. Studies on cognition and practice with regard to households′ production behavior are insufficient. Systematic studies on this topic are rare; therefore, there is little guidance for policy-makers.

Although previous research has provided a good foundation, most studies have only focused on the influence of one or several factors on the agricultural production mode or behavior. In reality, these factors associate and restrict mutually. For example, resource endowment determines family wealth to some extent and influences household attitude toward environmental protection. These direct or indirect influences and restrictions are difficult to analyze using simple one-to-one correspondence relationships. Further, the resulting agricultural production modes can provide feedback and influence the factors such as protection attitude and family wealth. This bidirectional and complicated interaction determines the complexity and difficulty of relative research. Systematic analysis on mutual relationships and influences among these factors can contribute to effective policy making and promote the sustainable management of nature reserves. However, there are less effective methods for relative analysis and research in the current challenge.

Structural equation model (SEM) is an empirical analysis method that can be used to overcome the difficulties inherent in such data (Asahs, 2008). This method has been widely used in many fields due to its advantages and positive features (Kuppum and Pendealar, 2001; Arhonditsis *et al*., 2006; Chen and Lin, 2010; Elrodt *et al*., 2012). In our research, we randomly selected four villages in and around Crested Ibis National Nature Reserve for conducting the survey. As population growth and nature reserve protection affect local development, the contradiction between protection and development is becoming increasingly ostensible. There are two important challenges confronted by Crested Ibis protection: 1) how to improve households′ protection attitude and encourage them to participate in reserve protection actively and voluntarily; and 2) how to improve local livelihood through environmental protection. Specifically, we investigated how household age, households′ education level, family wealth, and resources endowment affects households′ protection attitude. In addition, we explored how households′ age, family wealth, resources endowment, and protection attitude together affect household production behavior. The most important attribution of our research is the application of the SEM to analyze the coupling relationship among production mode, protection attitude, family wealth, and resources endowment in the analysis of cognition with respect to protection of the nature reserve.

## 2 Materials and Methods

### 2.1 Study area

The study area is located in Yang County (33°02′–33°43′N, 107°11′–108°33′E) and Ningshan County (33°07′–33°50′N, 108°02'–108°56'E) in Shaanxi Province, China (Fig. 1). The following four villages were randomly chosen: Caihe Village and Caoba Village in Yang County, and Caigou Village and Zhujiazui Village in Ningshan County. Yang County is an important habitat for Crested Ibis (*Nipponia Nippon*). It is situated between the Qinling Mountains and the Bashan Mountains with the Hanshui River running across, which provides favorable conditions for Crested Ibis, such as abundant natural food resources from a large number of small rivers, reservoirs and ponds, for Crested Ibis. Ningshan County is one of the experimental zones for Crested Ibis reintroduction. It is located south of mid-Qinling Mountains and also has many rivers and rich water resources. Both counties have low per capita cultivated land which is less than 0.067 ha per capita. The natural forest protection projects restrict the household felling of timber. Therefore, the conflict between human and land is prominent, thereby challenging for the local environment and the protection of Crested Ibis.

Prominent achievements have been recorded in the protection of the Crested Ibis in our research, with the number of Crested Ibis growing from 7 in 1981 to more than 700 in 2010 (Ding, 2010). Meanwhile, protection

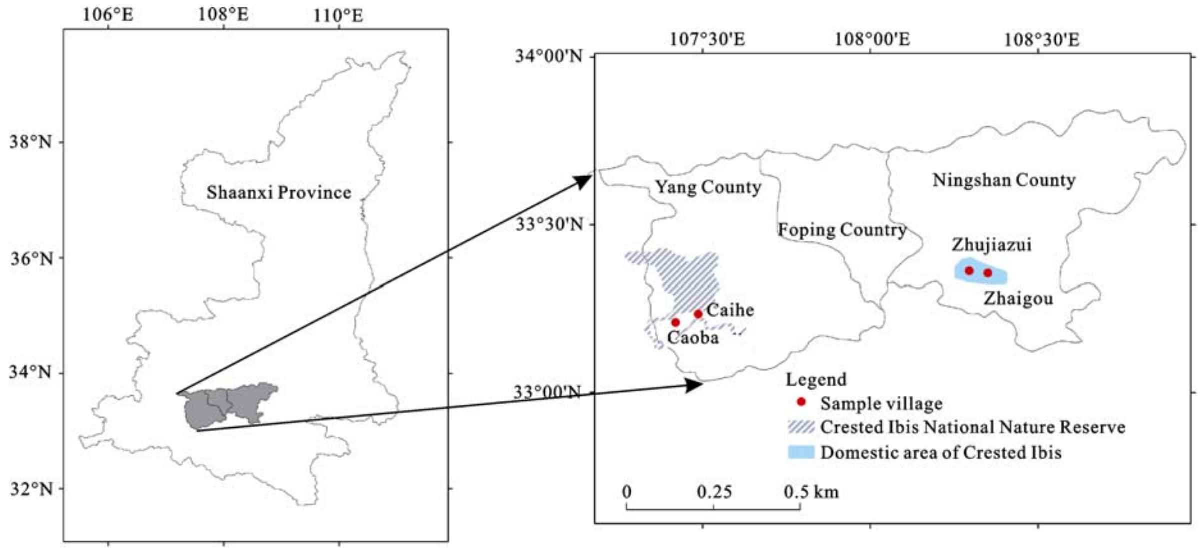


**Fig. 1** Location of study area

institutions increased household income by initiating development projects such as Crested Ibis Rice (also called green rice) and Organic Pears (Zhang *et al*., 2006; Wang *et al*., 2010a). Although there was an increase in the number of Crested Ibis, the protection mode adopted for the Crested Ibis limited household production and management behavior and also led to some behavior that is harmful to the Crested Ibis (Zhang *et al*., 2006), particularly in the Crested Ibis National Nature Reserve. Paddy fields in low mountains are the most important feeding areas for the adult Crested Ibis in the winter; thus, extensive use of pesticide and fertilizer could severely threaten the survival of the Crested Ibis and cause other problems such as soil pollution and soil hardening. Furthermore, in the breeding season, the Crested Ibis often choose to nest in trees around residential areas; therefore, firewood felling could impact Crested Ibis nesting. Meanwhile, firewood felling is often regarded as an index for environmental degradation or forest destruction (Biddlecom *et al.,* 2005). In brief, households' production and living behaviors are rather important in the protection of the Crested Ibis and its environment.

## 2.2 Methods

### *2.2.1 Data collection*

The survey data were sourced from the household questionnaires and interviews in the four randomly selected villages in Yang County and Ningshan County from January 1–17, 2012. The village head revealed basic information about the villages, the Crested Ibis, and their habitat. In order to receive authentic information from the households, we ensured that we were not accompanied by village cadre when interviewing farmers. Households were randomly selected for participation in the survey and the survey was conducted using face-to-face dialogue.

The questionnaire contained two parts: 1) the family information of household, which mainly included population statistics (age, gender, education level, *etc*.), family wealth (annual expenditure per capita, annual income per capita, *etc*.), production behavior (annual fertilizer use, annual pesticide use, and annual firewood use), resource endowment (paddy land area, dry land area, economic forest area); and 2) the analysis of households' attitude toward protection of the environment, the attitude toward protection of the Crested Ibis, and the willingness to protect the Crested Ibis. The questionnaire contained three options regarding the attitude toward protection of the environment: 1) 1 represented 'the environment should be protected by the government and have nothing to do with me'; 2) 2 represented 'I would protect the environment only if everybody else did'; 3) 3 represented 'I would protect the environment actively'. The questionnaire set up three options about the attitude toward protection of the Crested Ibis: 1) 1 represented 'the protection threatens my interests'; 2) 2 represented 'the protection has nothing to do with me'; 3) 3 represented 'the protection should be implemented strictly'. Finally, the questionnaire also contained three options regarding the households' willingness to protect the

Crested Ibis: 1) 1 represented 'unwillingness'; 2) 2 represented 'neutral attitude'; 3) 3 represented 'willingness'. The questionnaire also included some open-ended questions, such as the reason why households were unwilling to protect the Crested Ibis and advice for the policies of the nature reserves.

### *2.2.2 Structural equation model*

Structural equation model (SEM) is also called latent variable model (LVM). It was developed in the 1970s by Joreskog and Goldberger (1972). Initially, the SEM was widely used in the psychology and sociology research; thereafter, it began to be used in ecological and environmental research (Chen and Lin, 2010). In recent years, SEM has been increasingly used in management and economics research (Ülengin *et al*., 2010; Kaltenborn *et al*., 2012). One of the advantages of SEM is that it can analyze unobserved variables by measuring observable variables. There have been numerous improvements in SEM including the multiple indicators and multiple causes models (Chou and Bentler, 2002; Iacobucci, 2010).

Compared to other multiple variable statistic methods, SEM can better test the causal relationship between variables by modeling measurement error (Chen and Lin, 2010). A complete SEM model includes a measurement model and a structural model. The measurement model describes the interrelationship between observed variables and latent variables, while the structural model describes the relationship between different latent variables. Here, equations (1) and (2) represent the measurement model, and Equation (3) represents the structural model:

$$X = \Lambda_x \xi + \delta \tag{1}$$

$$Y = \Lambda_y \eta + \varepsilon \tag{2}$$

$$\eta = \beta\eta + \Gamma\xi + \zeta \tag{3}$$

where $X$ is the $q \times 1$ vector of exogenous observed variables including the five indices in two driving categories; $Y$ is the $p \times 1$ vector of observed responses, in this study which presents the 10 features indices in the four endogenous variables of vulnerability: conservation attitudes, production behaviors, resource endowment, and family wealth; $\xi$ is an $n \times 1$ vector of latent exogenous variables; $\eta$ is an $m \times 1$ vector of latent dependent or endogenous variables; $\Lambda_x$ is the $q \times m$ matrix of regression coefficients of $X$ on $\xi$; $\Lambda_y$ is the $p \times m$ matrix of coefficients of the regression of $Y$ on $\eta$; and $\delta$ and $\varepsilon$ are $q \times 1$ and $p \times 1$ vectors of measurement errors in $X$ and $Y$, respectively. In Equation (3), $\beta_{m\times m}$ is the structural coefficient matrix of the endogenous variables $\eta$; $\Gamma_{m\times n}$ is the effect of the structural coefficient matrix of exogenous variable $\xi$ to $\eta$; and $\zeta$ is the error vector and uncorrelated with $\xi$.

In this study, the exogenous variables ($\xi$) included resource endowment ($\xi_1$) and family wealth ($\xi_2$). Protection attitude ($\eta_1$) and production behavior ($\eta_2$) represented endogenous variables ($\eta$). The measurement model was used to measure the relationship among observed and latent variables, although it does not reflect the causal relationship between latent variables. Further, two measurable variables were added to make the SEM more accurate. The structural model achieved this aim with the transaction matrix. Therefore, the functional form of the estimated causal relationships is described as:

$$\eta_1 = \eta_1(\xi_1, \xi_2) \tag{4}$$

$$\eta_2 = \eta_2(\xi_1, \xi_2, \eta_1) \tag{5}$$

### *2.2.3 Model fit and research hypotheses*

SEM is a repetitive process that includes fitting, assessment, modification, and reevaluation, which aims to obtain statistically meaningful results (Lin, 2008). Parameter reasonableness, significance test, and fitness test are included in the reasonableness test of SEM. Model checking provides not only quantitative results for model reasonableness, but also direction for model modification and further study. The fit of SEM is usually evaluated by using chi-square statistics; however, sample size tends to influence these statistics. Thus, in this study, the overall fit of the model was assessed by using the normed fit index (NFI), the goodness of fit index (GFI), the comparative fit index (CFI), adjusted goodness of fit index (AGFI), and root mean square error approximation (RMSEA) (Schmidt *et al*., 2006; Zou, 2012). A value of 0.90 and above for NFI, CFI, and GFI is considered a good fit (Lee, 2007; Lin, 2008). The results of fit index of SEM are automatically given by the AMOS software (Table 1). The chi-square value divided by degrees of freedom was 1.05, which indicated excellent model fit. The values of GFI, NFI, AGFI, and CFI were all greater than 0.90, corresponding to a high degree of fit for the structural model. For RMSEA, the result was lower than 0.1, thereby indicating significant

**Table 1** Fitting index of SEM

| Fitting index | $x^2$ /d*f* | GFI | NFI | AFGI | CFI | RMSEA |
|---|---|---|---|---|---|---|
| Criterion | <3 | >0.9 | >0.9 | >0.9 | >0.9 | <0.1 |
| Result | 1.05 | 0.947 | 0.963 | 1.009 | 1.000 | 0.000 |

deviation between expected and observed covariance. Hence all the fitting indices of the SEM showed that the model was suitable for verifying and analyzing the research hypotheses.

The coupling model was debugged from the initial latent variable model (Fig. 2). Reliability analysis on model variables was conducted by using SPSS 17.0. The $\alpha$-value of each latent variable was greater than 0.7 (Table 2), thereby indicating that there was good consistency in model variables (Schmidt *et al*., 2006; Zou, 2012). We propose the following hypotheses in the current study:

Hypothesis 1 (H1): Family wealth has a positive effect on protection attitude;

Hypothesis 2 (H2): Resource endowment has a negative effect on protection attitude;

Hypothesis 3 (H3): Education level has a positive effect on protection attitude;

Hypothesis 4 (H4): Family wealth has a negative effect on production behavior;

Hypothesis 5 (H5): Resource endowment has a positive effect on production behavior;

Hypothesis 6 (H6): Education level has a negative effect on production behavior;

Hypothesis 7 (H7): Protection attitude has a negative effect on production behavior;

Hypothesis 8 (H8): The measurable variable is used as a valid indicator for measuring the corresponding latent variable.

## 3 Results and Discussion

### 3.1 Respondent's characteristics

In total, 449 questionnaires were obtained, with 255 from Yang County and 194 from Ningshan County. Of these, 13 questionnaires were excluded from the study due to incomplete or invalid responses; 436 valid questionnaires were analyzed.

The results of descriptive statistics of the samples are shown in Table 3. The average age of the respondents was 49.81 years, and their education level ranged from 3–12 years, with a mean value of 7.28 years. The annual per capita expenditure on chemical fertilizers was 1953.6 yuan/(ha·yr). The respondents that did not use chemical fertilizers around the protected areas accounted for 18.20% of respondents. The annual per expenditure on pesticides was 97.20 yuan / (ha·yr) and 42.24% of respondents did not use pesticides in planting. The annual per collection of firewood in the protected areas was 2298.83 kg/household and only 3.49% of respondents did not collect firewood. The annual per income was 8172.26 yuan on average (S.D. = 6053.07), and the annual per capita expenditure was 4312.78 yuan (RMB) on average (S.D. = 3398.07). This suggested an

**Table 2** Reliability of latent variables

| Latent variable | Observed variable | $\alpha$-value |
|---|---|---|
| Protection attitude ($\eta_1$) | Attitude toward protection of environment ($Y_1$) | 0.895 |
| | Attitude toward protection of Crested Ibis ($Y_2$) | |
| | Willingness to protect Crested Ibis ($Y_3$) | |
| Production behavior ($\eta_2$) | Annual fertilizer use ($Y_4$) | 0.758 |
| | Annual pesticide use ($Y_5$) | |
| | Annual firewood use ($Y_6$) | |
| Resource endowment ($\xi_1$) | Paddy land area ($X_1$) | 0.841 |
| | Dry land area ($X_2$) | |
| | Economic forest area ($X_3$) | |
| Family wealth ($\xi_2$) | Logarithm of income per capita ($X_4$) | 0.804 |
| | Logarithm of expenditure per capita ($X_5$) | |

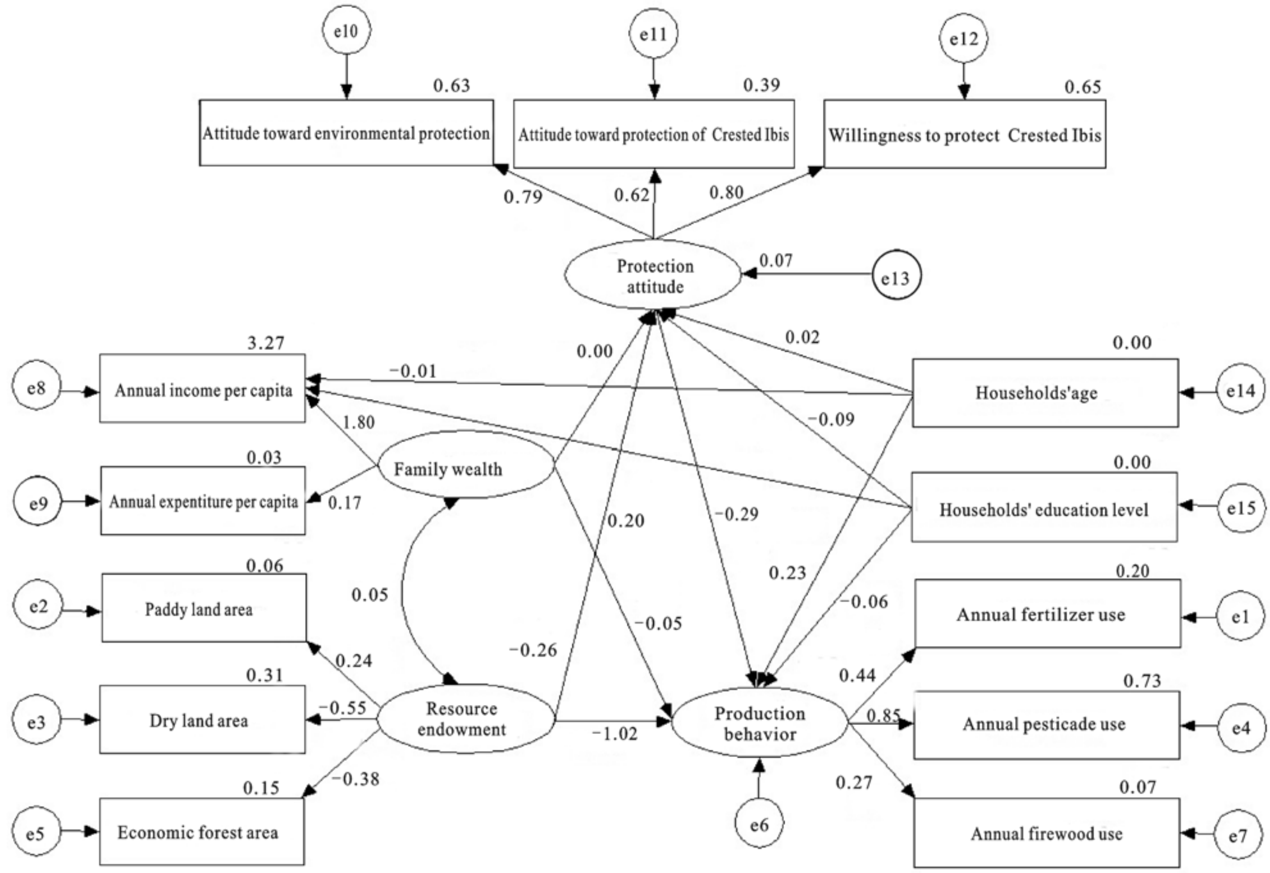


**Fig. 2** Coupling relationship of households′ protection attitudes, production behaviors, resources endowment, and family wealth in and around Crested Ibis National Nature Reserve

**Table 3** Results of descriptive statistics of samples

| Variable name | Variable type | Min | Max | Mean | S.D. | Variable explanation |
|---|---|---|---|---|---|---|
| Households′ age | Quantitative | 25 | 80 | 49.81 | 13.65 | According to the actual value |
| Households′ education level | Quantitative | 3 | 12 | 7.28 | 2.77 | According to the actual value |
| Annual fertilizer use (yuan/(ha·yr)) | Quantitative | 0 | 8392.24 | 1953.60 | 2784.75 | Equals annual usage amount |
| Annual pesticide cost (yuan/(ha·yr)) | Quantitative | 0 | 499.24 | 97.20 | 158.27 | Equals annual usage amount |
| Annual firewood use (kg/(household·yr)) | Quantitative | 0 | 6031.54 | 2298.83 | 3069.63 | Equals annual usage amount |
| Annual income per capita (yuan/household·yr) | Quantitative | 415.25 | 12708.24 | 8172.26 | 6053.07 | Equals annual family income divided by number of family members |
| Annual expenditure per capita (yuan/(household·yr)) | Quantitative | 304.52 | 10371.25 | 4312.78 | 3398.07 | Equals annual family expenditure divided by number of family members |
| Paddy land area (ha/household) | Quantitative | 0.5 | 8 | 1.85 | 1.59 | According to the actual value |
| Dry land area (ha/household) | Quantitative | 0.5 | 12 | 2.54 | 2.52 | According to the actual value |
| Economic forest area (ha/household) | Quantitative | 0.5 | 22 | 2.11 | 3.74 | According to the actual value |
| Attitude toward protection of environment | Categorical | 1 | 3 | 2.49 | 0.85 | 1: bad; 2: not good; 3: good |
| Attitude toward protection of Crested Ibis | Categorical | 1 | 3 | 2.43 | 0.85 | 1: bad; 2: not good; 3: good |
| Willingness to protect Crested Ibis | Categorical | 1 | 3 | 2.50 | 0.74 | 1: unwillingness; 2: unknown; 3: willingness |

uneven income distribution in the sampling areas. With regard to attitude toward protection of the environment, 12.93% respondents chose 'the protection had nothing to do with me', 9.48% chose 'I would protect the environment if others do', and 77.59% chose 'I should protect the environment actively'. With regard to the attitude toward protection of the Crested Ibis, 8.62% of households chose 'protection threatened my interests', 22.41% chose 'protection has nothing to do with me', and 68.97% chose 'protection should be implemented strictly'. With regard to willingness to protect the Crested Ibis, 10.34% chose 'unwilling', 13.79% chose 'neutral attitude', and 75.86% chose 'willing'.

### 3.2 Results of testing hypotheses

SEM parameter estimation is the quantification of the relationship among latent variables, between a latent variable and an observation variable, or among related observation variables (Arhonditsis *et al*., 2006). Generally, two methods are used for this purpose: maximum likelihood estimation and generalized least square method (Sutton-Grier *et al*., 2010). Our study used the maximum likelihood estimation to estimate the mode parameters and AMOS 17.0 to analyze the data. The fitting results of this mode-specific path are shown in Table 4 and Fig. 2; all path coefficients were found to be significant (Table 4).

**Table 4** Fitting results of SEM

| Path | | | Estimate | S.E. | C.R. | *P*-value |
|---|---|---|---|---|---|---|
| $\eta_1$ | ← | HA | 0.001 | 0.004 | 0.188 | 0.051 |
| $\eta_1$ | ← | $\xi_2$ | 0.001 | 0.020 | –0.066 | 0.047 |
| $\eta_1$ | ← | HEL | –0.019 | 0.021 | –0.921 | *** |
| $\eta_1$ | ← | $\xi_1$ | –0.377 | 0.302 | –1.245 | *** |
| $\eta_2$ | ← | $\xi_2$ | –0.027 | 0.164 | –0.163 | *** |
| $\eta_2$ | ← | HA | 0.015 | 0.007 | 2.159 | 0.031 |
| $\eta_2$ | ← | HEL | –0.018 | 0.029 | –0.616 | *** |
| $\eta_2$ | ← | $\xi_1$ | –2.362 | 1.363 | –1.733 | *** |
| $\eta_2$ | ← | $\eta_1$ | –0.450 | 0.294 | –1.531 | 0.126 |
| $Y_2$ | ← | $\eta_1$ | 0.722 | 0.123 | 5.883 | *** |
| $Y_1$ | ← | $\eta_1$ | 1.000 | | | |
| $Y_3$ | ← | $\eta_1$ | 0.956 | 0.149 | 6.401 | *** |
| $X_3$ | ← | $\xi_1$ | –3.800 | 1.896 | –2.005 | 0.045 |
| $X_1$ | ← | $\xi_1$ | 1.000 | | | |
| $X_2$ | ← | $\xi_1$ | –3.715 | 1.705 | –2.179 | *** |
| $Y_5$ | ← | $\eta_2$ | 2.363 | 0.654 | 3.614 | *** |
| $Y_4$ | ← | $\eta_2$ | 1.000 | | | |
| $Y_5$ | ← | $\eta_2$ | 0.508 | 0.222 | 2.294 | *** |
| $X_4$ | ← | HA | –0.001 | 0.006 | –0.144 | 0.086 |
| $X_4$ | ← | HEL | 0.067 | 0.030 | 2.260 | *** |
| $X_5$ | ← | $\xi_2$ | 0.109 | 0.641 | 0.170 | *** |
| $X_4$ | ← | $\xi_2$ | 1.000 | | | |

Notes: HA, Households' age; HEL, Households' education level

#### *3.2.1 Results of hypothesis 1*

The impact of family wealth on the attitude toward protection of the environment was positive with the path coefficient being 0.001, which implied that as family wealth changed by one standard deviation (S.D.), the households' protection awareness increased by 0.001 S.D. This low coefficient indicated that the impact of family wealth on the households' protection attitude was small. But the positive coefficient suggested that the households' protection attitude would increase with the increase of family wealth, which supported hypothesis 1 of our research. Our results were similar to many other studies, which thought the households with more family wealth were less dependent on the resources in the nature reserve and thus had better protection attitude (Khadka and Nepal, 2010). We found in the interviews, households with more family wealth had more family members, and the able-bodied adults went out to work for receiving more money. They had higher quality of life and be out of poverty. For a long time, the natural disasters took place frequently in the Qinling Mountains areas, especially mudslides. Households with more family wealth are willing to support the construction of village infrastructure within the scope of their ability, which would give them better living environment. Apiculture is a kind of traditional aquaculture in survey areas because of abundant forest resources. The apiculture has been keeping households with more family wealth. They thought that the better ecological environment may improve further development of their apiculture, which would make them having positive attitude toward protection of the environment.

#### *3.2.2 Results of hypothesis 2*

The impact of resource endowment on the attitude toward protection of the environment was negative with the path coefficient being –0.377, which meant that as resource endowment increased by one S.D., households' protection attitude decreased by 0.377 S.D. The negative path coefficient suggested that households with more resource endowment had greater conflicted with the protection and thus bore more protection costs, thereby resulting in a negative attitude toward protection. This supported hypothesis 2. The larger path coefficient indicated that resource endowment was one of the key factors influencing households′ protection attitude. In particular, in our study area (Crested Ibis National Nature Reserve), households with a greater amount of cultivated land incurred greater protection costs because the protection of the Crested Ibis required a restriction on the use of fertilizers and pesticides. Moreover, we found that the damage of crops by wild animals was widespread. Thus, households with greater amount of cultivated land bore bigger losses, which further impacted their attitudes toward protection. This was consistent with other scholars′ conclusions. In the Wildlife Reserve in Selous, households with more cultivated lands strongly opposed conservation programs due to increased crop damage and related opportunity costs (Gadd, 2005; Songorwa *et al.*, 2000). In Laikipia, Kenya, households perceived the negative impacts of wildlife protection mainly in terms of crop damage and dangerous wildlife. The households with more cultivated land had a passive attitude toward protection due to the higher costs (Gadd, 2005; Zhou *et al.*, 2012).

#### ***3.2.3 Results of hypothesis 3***

The impact of education level on households′ protection attitude was negative with the path coefficient being –0.019. This did not support our hypothesis 3, which stated that households with a higher education level had a more positive protection attitude, although scholars believed that households with a higher education level had a better understanding of protection (Mcclanahan *et al*., 2005). In addition, households' education level was the key for greater employment opportunities, reducing households' dependence on resources, thereby mitigating the conflicts between resources and protection (Kideghesho *et al*., 2007). However, by variance analysis, our research further showed that when households had a low level of education (primary level or illiteracy), their protection attitudes improved through education regarding environmental protection (Shi and Liao, 2012). However, when households had junior middle school education and above, their protection attitudes were not significantly impacted by further education regarding environmental protection. It is possible because the households′ protection attitude was toward their own interests. Along with further education, households had clear opinions on the conflicts between protection and their interests and thus they might not support protection work for their own interests. Allendorf (2007) found that households with higher education level had more negative protection attitude in three nature reserves in Nepal (Nepal and Spiteri, 2011). Similarly, Songorwa *et al*. (2000) also found that households with a higher education level might be more likely to oppose protection in Alessio Ross Reserves. The reason was that the protection attitude also was impacted by many other factors. The path coefficient of the household age to protection attitude was 0.001, which indicated that the age was not an important factor influencing protection attitude.

#### ***3.2.4 Results of hypothesis 4***

The path coefficient of family wealth on household production and management behaviors was –0.026, which implied that as family wealth changed by one S.D., the use of pesticides, fertilizers and firewood decreased by 0.026 S.D. This suggested that the households with more family wealth might use less pesticides, fertilizers, and firewood, which verified hypothesis 4. Further, we found that income from migrant work was the main source for local household income with 65.67% and 60.07% of total annual income in Yang County and Ningshan County, respectively. Thus, household with more family wealth had more migrant workers. This might lead to two results: 1) when the household income came from migrant work, the pressure of community on the environment was relieved because the relationship between the household and rural environment changed (i.e., the household dependence on the rural environment was lower, and a lot of surplus labor went outside); and 2) as the migrant workers were mainly young adults, they could be influenced by new thoughts and concepts, which could have effects on local agricultural production mode and resources use mode (Wang *et al*., 2010b).

#### ***3.2.5 Results of hypothesis 5***

The path coefficient of resource endowment on production and management behaviors was –2.192. This did not support hypothesis 5, which stated that the household with more resource endowment used more pesticides, fertilizers, and firewood. However, through further study, we also found that the nature reserve strictly restricted household use of pesticides and fertilizers to protect of the Crested Ibis, particularly for those farmers who own large areas of cropland. In contrast to small cropland farmers, households with more cultivated lands bore greater restrictions by the nature reserve and used less pesticides and fertilizers. Another reason could be that respondents who owned large cultivated areas did not reveal the actual usage amounts of pesticides and fertilizers in order to avoid getting into trouble. Although both these possible explanations seem reasonable, determining which one is dominating requires further exploration.

#### *3.2.6 Results of hypothesis 6*

The impact of education level on household production and management behaviors was negative with the path coefficient being –0.010, which indicated that households with higher education level displayed production and management behavior that was less harmful to the environment. This finding supported hypothesis 6. The path coefficient of household age was 0.015, which suggested that older households might use more pesticides, fertilizers, and firewood because they paid more attention to short-term investments. Further, the path coefficient of households′ education level and household age on household production and management behaviors was small, which implied that the two characteristic variables were not major factors impacting production and management behaviors.

#### *3.2.7 Results of hypothesis 7*

The path coefficient of households′ protection attitude on the production behaviors was –0.045, which meant that when household protection attitude changed by one S.D., their behaviors that are harmful to the environment decreased by 0.045 S.D. This indicated that the improvement of households′ protection attitude benefited environmental protection in production and living behaviors, which supported hypothesis 7. However, this path coefficient was not significant. This indicated that only when households benefited from protection and realized the connection between protection and livelihood, they promoted the implementation of protection in ecologically sensitive areas with a backward economy and severe conflicts between humans and land (Nepal and Spiteri, 2011). In other words, the improvement in households’ protection attitude benefited their production and living behaviors related to environmental protection. However, the path coefficient was not significant, thereby indicating that only when households benefited from protection would they work toward the success of environmental protection.

#### *3.2.8 Results of hypothesis 8*

All path coefficients of observed variables to corresponding latent variables were significant (Table 4); therefore we conclude that dry land area, paddy land area, and economic forest area could be used as variables for measuring households′ resource endowment. Further, the use of chemical fertilizers, pesticides, and collection of firewood could be used as variables for measuring household production and management behaviors. Attitude toward protection of the environment, attitude toward protection of the Crested Ibis, and willingness to protect the Crested Ibis could be used as variables measuring households′ protection attitude. The logarithm of per capita income and per capita expenditure were good variables for measuring households′ family wealth. This showed that the results of SEM in this study were in accordance with hypothesis 8.

## 4 Conclusions and Suggestions

In this study, we used SEM for determining coupling relationships among protection attitude, production behavior, resource endowment, and family wealth. Through model evaluation, we found that the model reflected the relationships among variables well and had a high fitting degree. First, households with greater resource endowment had more negative attitudes, probably due to the greater protection costs incurred by them; moreover, householders with higher education levels had worse protection attitudes. Second, households with greater family wealth were more likely to use fewer fertilizers, pesticides, and firewood; households with more resource endowment engaged in less production and management behavior to protect the environment; the enhancement of household attitudes led to an improvement of production behavior to protect the environment; however, the effects were not statistically significant. Our results provide a basis for policy making by the government for environmental protection, thereby enabling the exploration of effective management measures for both nature reserve management and community development. The following suggestions can be made on the basis of our results: 1) Establish or improve the economic compensation mechanisms of nature reserves, as wild animals do great harm to crops. However, since they are protected animals, local residents can not hunt them; therefore, the economic losses caused by such animals are not compensated for. Although some economic compensation measures were established by relative departments, they were not put into effect. This situation greatly frustrated the enthusiasm for local biodiversity protection. Therefore, the administrative authorities must adopt measures to implement and improve local economic compensation. This can mitigate the conflicts between the administrative authorities and nature reserves and improve the enthusiasm for conservation among households. 2) Enhance education on environmental protection for farmers. The results showed that education was not positively correlated with the perception of ecological protection. Thus, the management of the nature reserves should enhance propaganda to ensure that local farmers fully understand the strategic significance of environmental protection, particularly the younger generation. This has currently become one of the important missions for nature reserve protection. Thus, we believe that the local government or management organization should host propaganda and provide knowledge related to nature reserves in the communities around the nature reserves. Meanwhile, newspapers and propagandistic handbooks should be distributed among the householders. Of course, the basic premise of enhanced education was giving hope to farmers in order to improve their attitude toward nature protection. 3) Help households in developing the economy. Due to the establishment of the nature reserve, local resource development became limited and this influenced the economic development of the community. Most nature reserves are located in remote mountainous areas and their resident lives are difficult. Thus, the management organizations of the nature reserves must become responsible for the economic development of local communities and the wealth of the farmers. This will reduce household dependence on land production and thus lessen the environmental destruction caused by production behavior. Therefore, the cooperative development of tourism with local communities or entrusting tourism to local communities must be seriously considered. Above all, local farmers should be given alternative employment to enhance their benefits. Further, the government can also enable farmers to develop the planting industry (e.g., fungi culture).

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