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Research Article

Assessing Relationships between Peasant Household Livelihood Assets and Regional Agricultural Pollution in China Using Grey Correlation Analysis

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Abstract: The peasant household livelihood assets affect the choice of livelihood strategies which may has the potential to contaminate or degrade the environment. Using grey correlation analysis, this study aims to analyze the correlation between peasant household livelihood assets and regional agricultural pollution in China. Based on the grey correlation analysis procedure, using the related indicators materialized the peasant household livelihood assets and regional agricultural pollution, the results show that intensive farming practices which are affected by livelihood assets induce more agricultural pollution emission in Eastern district. Human capital and physical capital play a key role on affecting the amount of agricultural pollution emission in Middle district. Physical capital, natural capital and financial capital have great influence on regional agricultural pollution in Western district. Therefore the specific policies targeted at controlling regional agricultural pollution should pay more attention to optimizing the peasant household livelihood assets and helping them to adopt suitable livelihood strategies.

Keywords: Agricultural pollution, China, grey correlation analysis, livelihood assets, peasant household

INTRODUCTION

In recent years, agricultural pollution has become a huge environmental problem in China. In order to improve food security in China, intensive farming practices are adopted widely in rural regions to produce more agricultural production (Shen *et al*., 2013; Dai and Dong, 2014). Most Chinese peasant households today utilize excessive inputs such as fertilizers, pesticides and labor in limited agricultural land to increase productivity. However the byproducts of intensive farming practices has the potential to contaminate or degrade the environment or cause significant injury to human health. For example, the applied nitrogen and phosphorus via fertilizers lead to eutrophication in rivers or lakes (Buckley and Carney, 2013). Pesticide that is not rapidly degraded leaches through the soil to drainage water and groundwater and pesticide leaching may cause pesticide-related health problems among farmers (Leistra and Boesten, 2010).

The peasant household livelihood assets affect the choice of livelihood strategies to fit for their resource capabilities (Soltani *et al*., 2012; Belay and Bewket, 2013; Jakobsen, 2013; Diniz *et al*., 2013). The peasant households earn a living by combining the individual or household's livelihood assets. And they pursue diversified strategies to achieve their livelihood goals (Tesfaye *et al*., 2011). In Ethiopia, farmers' livelihood assets, such as plot distance from residence, land to man ratio, use of dung for fuel and number of livestock owned, determined continued use of introduced land management technologies. The introduced land management technologies could help to reduce soil erosion and soil fertility depletion (Belay and Bewket, 2013). And the Irish farm households adopted pluriactive as a key strategy to maintain the standard of living desired by farm households since poor livelihood assets such as small size of farm holdings, relatively poor quality land and a predominance of beef. It stressed that the pluriactive was one important factor to protect rural nature and landscape in rural areas (Kinsella *et al*., 2000). Consequently this study tries to analyze the correlation between peasant household livelihood assets and regional agricultural pollution in China.

METHODOLOGY

The relationships between peasant household livelihood assets and regional agricultural pollution are complicated. However, there is lack of precious quantitative researches on these relationships. Grey correlation analysis is suitable for solving the problems without any prior knowledge of the research objectives (Tsai and Hsu, 2010; Zhang and Feng, 2013). It is selected to analyze the correlation between peasant household livelihood assets and regional agricultural pollution in China. The detailed steps are as follows.

I assume that there are m original son sequences and n original father sequences in p-th province in China. In empirical study, grey correlation analysis is applied to computer values of correlation between

peasant household livelihood assets and regional agricultural pollution. Therefore the son sequences correspond to peasant household livelihood assets and the father sequences correspond to agricultural pollution.
The original son sequences are defined as follows:

$$\left\{X_1^{(0)}(p), X_2^{(0)}(p), \cdots X_m^{(0)}(p)\right\}$$

The original father sequences are defined as follows:

$$\left\{Y_1^{(0)}(p), Y_2^{(0)}(p), \cdots Y_n^{(0)}(p)\right\}$$

Original sequences should be transformed to eliminate dimension. The transformation equation for original son sequences is defined as follows:

$$X_m(p) = \frac{X_m^{(0)}(p)}{\sum^{t} X_m^{(0)}(p)} t \quad (1)$$

where, t is the number of provinces. The transformation equation for original father sequences is similar to Eq. (1). Then the grey correlation coefficient L_{ij} (k) is defined as follows:

$$L_{ij} = \frac{\Delta_{\min} + \rho\Delta_{\max}}{\left|Y_i(k) - X_j(k)\right| + \rho\Delta_{\max}} \quad (2)$$

where,
$L_{ij}(k)$ = The grey correlation coefficient between the i-th and the j-th of the k-th province
$\triangle_{max}$ = The maximum of absolute difference
$\triangle_{min}$ = The minimum of absolute difference
ρ = Recognition coefficient and it is selected as 0.1 in this study

The grey correlation degree R_{ij} is an average of the grey correlation coefficients and is defined as follows (Deng, 1989):

$$R_{ij} = \frac{1}{p}\sum_{k=1}^{p} L_{ij}(k) \quad (3)$$

CASE STUDY

Study area: This study assesses the correlation between peasant household livelihood assets and regional agricultural pollution at provincial level in China. The administrative division in China has 34 provincial level divisions which are classified as 23 provinces (including Taiwan), 4 municipalities, 2 special administrative regions in 2014. Hong Kong, Macao and Taiwan did not include in this study since the lack of original data and 31 provinces were selected for analysis. Due to distinct difference in natural, economic and social features in 34 provinces in China,

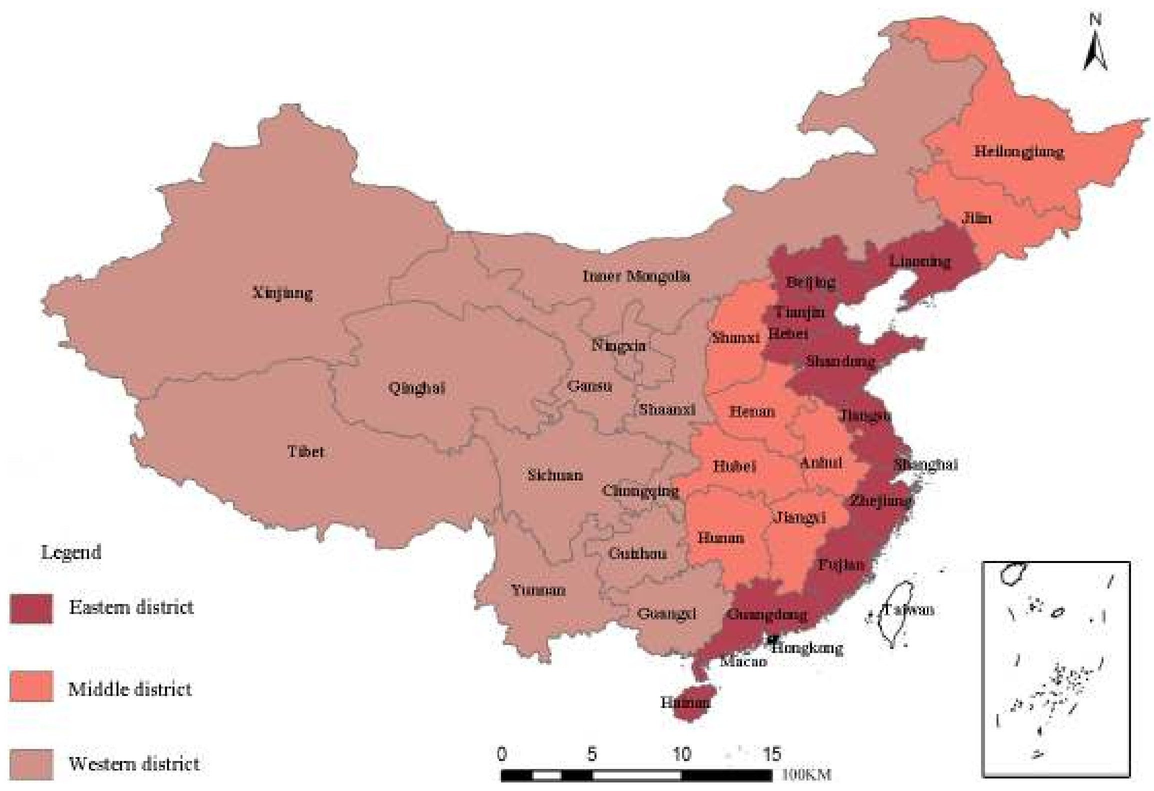

Fig. 1: Three districts in China

China is partitioned into Western district, Middle district and Eastern district according to "7th Five-Year" Plan in China. China's Western Development Program whose aim is narrowing the gap between the east coast and the western region has began since 2000 and this important police covers 6 provinces, 5 autonomous regions and 1 municipality. Therefore the region partition in "7th Five-Year" Plan is adjusted to suit China's Western Development Program. The provinces that compose three districts in this study are as follows (Fig. 1).

Eastern district in China consists of Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan.

Middle district in China consists of Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan.

Western district in China consists of Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

Indicators: The indicators were selected to materialize the peasant household livelihood assets and regional agricultural pollution. The two main criteria of selection were available for the entire study area and relevant to the peasant household livelihood assets or regional agricultural pollution. Livelihood assets can be divided into five types of capital: human capital, natural capital, physical capital, financial capital and social capital (Ellis, 1998). With respect to human capital, household labor and literacy rate were selected. For natural capital, farmland area per capita and original value of productive fixed assets were selected. Regarding physical capital, chemical fertilizer consumption per household and pesticide consumption per household were selected. For financial capital, the core indicator was net income per capita of peasant household. Agricultural pollution mainly concerned with chemical oxygen demand, ammonia nitrogen emission, total nitrogen emission, total phosphorus emission. Quantity of agricultural pollution discharged is the sum of chemical oxygen demand, ammonia nitrogen emission, total nitrogen emission and total phosphorus emission. The indicators are presented in Table 1.

Data gathering: The data of 7 indicators used in materialize the peasant household livelihood assets including household labor, literacy, farmland area per capita, original value of productive fixed assets, chemical fertilizer consumption per household, pesticide per household and net income per capita of peasant household can be found in China Yearbook of Household Survey 2013. The data of chemical oxygen demand, ammonia nitrogen emission, total nitrogen emission and total phosphorus emission used to compute the agricultural pollution emissions can be found in China Environment Yearbook 2013. The descriptive statistics of indicators are provided in Table 2.

Using Eq. (1), the transformed values of household labor, literacy, farmland area per capita, original value of productive fixed assets, chemical fertilizer consumption per household, pesticide per household, net income per capita of peasant household and agricultural pollution in Eastern district, Middle district

Table 1: Indicators selected in this study

Categories	Components	Indicators	Units
Peasant household livelihood assets x	Human capital	Household labor x_1	Person
		Literacy rate x_2	%
	Natural capital	Farmland area per capita x_3	Mu/person
		Original value of productive fixed assets x_4	Yuan/household
	Physical capital	Chemical fertilizer consumption per household x_5	Kg/household
		Pesticide consumption per household x_6	Yuan/household
	Financial capital	Net income per capita of peasant household x_7	Yuan/person
Agricultural pollution y		Chemical oxygen demand y_1	10^4t
		Ammonia nitrogen emission y_2	10^4t
		Total nitrogen emission y_3	10^4t
		Total phosphorus emission y_4	10^4t

Table 2: Statistical description of indicators

Indicators	Obs.	Min.	Max.	Mean	S.D.
x_1	31	2.10	3.40	2.73	0.29
x_2	31	64.00	99.00	93.72	6.76
x_3	31	0.26	13.56	2.59	3.01
x_4	31	4146.10	52935.10	17865.72	9768.10
x_5	31	84.20	1862.20	645.32	422.20
x_6	31	8.80	834.90	316.74	196.23
x_7	31	4506.70	17803.70	8495.28	3339.76
y_1	31	0.40	134.40	37.22	34.01
y_2	31	0.05	7.40	2.60	2.14
y_3	31	0.60	56.30	14.56	12.86
y_4	31	0.04	6.10	1.58	1.42

Min.: Minimum; Max.: Maximum; S.D.: Standard deviation

Table 3: Transformed values of indicators in eastern district

Provinces	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y
Beijing	0.904	1.022	0.410	0.848	0.222	0.329	1.395	0.183
Tianjin	0.904	1.010	1.294	1.164	0.719	0.836	1.188	0.240
Hebei	1.061	1.008	1.548	1.190	1.342	1.028	0.684	2.078
Liaoning	0.943	1.018	3.096	1.661	2.165	1.453	0.795	1.724
Shanghai	0.825	1.012	0.213	0.276	0.239	0.245	1.508	0.081
Jiangsu	0.982	0.977	1.024	0.966	1.253	1.139	1.033	0.947
Zhejiang	0.943	0.964	0.442	1.513	0.393	0.641	1.232	0.510
Fujian	1.061	0.993	0.598	0.786	0.867	1.074	0.844	0.542
Shandong	0.982	0.997	1.343	1.274	1.901	1.336	0.800	3.115
Guangdong	1.257	1.004	0.434	0.566	0.845	1.186	0.893	1.340
Hainan	1.139	0.996	0.598	0.757	1.055	1.733	0.627	0.241

$y = y_1 + y_2 + y_3 + y_4$, similarly hereinafter

Table 4: Transformed values of indicators in middle district

Provinces	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y
Shanxi	0.897	1.011	0.618	0.632	0.576	0.301	0.829	0.364
Jilin	0.933	1.017	2.046	1.608	2.104	1.207	1.121	0.849
Heilongjiang	0.897	1.018	3.354	2.031	1.584	1.821	1.122	1.729
Anhui	1.005	0.953	0.468	0.976	0.747	0.850	0.934	0.795
Jiangxi	1.076	0.998	0.388	0.645	0.715	1.261	1.021	0.506
Henan	1.040	0.990	0.401	0.837	0.771	0.425	0.981	1.699
Hubei	1.112	1.001	0.423	0.697	0.864	1.125	1.024	0.944
Hunan	1.040	1.013	0.302	0.574	0.640	1.011	0.970	1.114

Table 5: Transformed values of indicators in western district

Provinces	x_1	x_2	x_3	x_4	x_5	x_6	x_7	y
Inner Mongolia	0.872	1.061	3.629	1.335	1.449	1.116	1.267	2.859
Guangxi	1.116	1.087	0.478	0.538	1.302	2.076	1.000	1.157
Chongqing	0.977	1.070	0.450	0.558	0.514	0.514	1.229	0.613
Sichuan	0.977	1.032	0.398	0.625	0.706	0.993	1.165	2.622
Guizhou	0.977	1.002	0.412	0.543	0.531	0.298	0.791	0.380
Yunnan	0.977	1.020	0.558	0.864	0.953	1.507	0.902	0.526
Tibet	1.186	0.716	0.660	2.404	0.123	0.035	0.952	0.031
Shaanxi	0.977	1.050	0.530	0.557	1.056	0.801	0.959	0.952
Gansu	1.012	0.999	0.949	0.885	1.522	0.704	0.750	0.628
Qinghai	0.977	0.914	0.639	0.996	0.336	0.352	0.893	0.096
Ningxia	0.942	0.959	1.288	1.102	1.127	0.874	1.029	0.414
Xinjiang	1.012	1.091	2.010	1.593	2.381	2.730	1.064	1.723

Table 6: Grey correlation degree between peasant household livelihood assets and regional agricultural pollution

y	x_1	x_2	x_3	x_4	x_5	x_6	x_7
Eastern district	0.338	0.307	0.438	0.386	0.416	0.405	0.277
Middle district	0.387	0.397	0.254	0.338	0.420	0.474	0.376
Western district	0.362	0.343	0.415	0.366	0.432	0.455	0.376

and Western district are presented in Table 3 to 5, respectively.

RESULTS AND DISCUSSION

Based on the grey correlation analysis procedure, using the related indicators, the correlation degree between peasant household livelihood assets and regional agricultural pollution in Eastern district, Middle district and Western district in China were computed (Table 6).

The correlation between peasant household livelihood assets and regional agricultural pollution in Eastern district in descending order was farmland area per capita>chemical fertilizer consumption per household>pesticide consumption per household> original value of productive fixed assets>household labor>literacy rate>net income per capita of peasant household. In Eastern district, the peasant household livelihood assets including farmland area per capita, chemical fertilizer consumption per household, pesticide consumption per household and original value of productive fixed assets significantly correlate with the regional agricultural pollution. It reveals that intensive farming practices which are affected by livelihood assets induce more agricultural pollution emission in Eastern district in China. The peasant households require large amounts of input of agricultural production, such as chemical fertilizer and pesticide, to produce adequate product since a large population with relatively little agricultural land in Eastern district. However, the process of agricultural pollution stems from intensive farming practices of peasant households.

The correlation between peasant household livelihood assets and regional agricultural pollution in Middle district in descending order was pesticide consumption per household>chemical fertilizer consumption per household>literacy rate>household labor>net income per capita of peasant household> original value of productive fixed assets>farmland area per capita. In Middle district, the peasant household livelihood assets including pesticide consumption per household, chemical fertilizer consumption per household, literacy rate and household labor significantly correlate with the regional agricultural pollution. It reveals that human capital and physical capital play a key role on affecting the amount of agricultural pollution emission in Middle district in China. Many provinces in Middle district are main grain production area and the agricultural pollution is increased since improper use physical capital which has a grave impact on the rural ecology. The human capital represents the skills, knowledge and ability that peasant households to pursue livelihood strategies. More household labor and higher educational attainment of peasant households imply labor input may accompany contamination or degradation of ecology in Middle district.

The correlation between peasant household livelihood assets and regional agricultural pollution in Western district in descending order was pesticide consumption per household>chemical fertilizer consumption per household>farmland area per capita>net income per capita of peasant household>original value of productive fixed assets>household labor>literacy rate. In Western district, the peasant household livelihood assets including pesticide consumption per household, chemical fertilizer consumption per household, farmland area per capita and net income per capita of peasant household significantly correlate with the regional agricultural pollution. It reveals that physical capital, natural capital and financial capital have great influence on regional agricultural pollution. The agricultural productivity in Western district in China is relatively low since severe natural production condition. And the peasant households have to improve their livelihoods according livelihood assets by discharging more agricultural pollution.

CONCLUSION

The peasant household livelihood assets affect the choice of livelihood strategies which may has the potential to contaminate or degrade the environment. In this study, grey correlation analysis was selected to analyze the correlation between peasant household livelihood assets and regional agricultural pollution. Household labor, literacy rate, farmland area per capita, original value of productive fixed assets, chemical fertilizer consumption per household, pesticide consumption per household, net income per capita of peasant household, chemical oxygen demand, ammonia nitrogen emission, total nitrogen emission, total phosphorus emission were designed to materialize the peasant household livelihood assets and regional agricultural pollution.

Based on the grey correlation analysis procedure, the results show that the correlation between peasant household livelihood assets and regional agricultural pollution in Eastern district in descending order was farmland area per capita>chemical fertilizer consumption per household>pesticide consumption per household>original value of productive fixed assets>household labor>literacy rate>net income per capita of peasant household, the correlation in Middle district in descending order was pesticide consumption per household>chemical fertilizer consumption per household>literacy rate>household labor>net income per capita of peasant household>original value of productive fixed assets>farmland area per capita and the correlation in Western district in descending order was pesticide consumption per household>chemical fertilizer consumption per household>farmland area per capita>net income per capita of peasant household>original value of productive fixed assets>household labor>literacy rate. It reveals that the peasant household livelihood assets have different influences on the regional agricultural pollution in different districts. Therefore the specific policies targeted at improving regional agricultural pollution should pay more attention to optimizing the peasant household livelihood assets and helping them to adopt suitable livelihood strategies.

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