Economic Benefit Evaluation and Application of Northwest Rural Eco-campus Based on Principal Component Projection Model

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Abstract Financial cost benefit (investment yield, financial net present value, benefit-cost ratio), social and economic benefits (saving rate of medical cost, average household income rate of trained farmers), technical and economic benefits (toilet-flushing water saves, pests and disease reduce rate, fruit or vegetable increase rate, and improve rate of technical skill level), and ecological and economic benefits (saving rate of afforestation cost, reduction of CO_2 discharge, reduction of SO_2 discharge, soil improvement, fertilizer saving rate) are selected. According to the original survey data of eco-campus economic benefits with 3 different models, Principal Component Projection is used to discuss the calculation method for evaluation index weight of economic benefits in northwest rural eco-campus, and to establish the principal component projection model of eco-campus economic benefits after the normalization processing of index value by efficiency coefficient transformation method based on dimensionless treatment of matrix element. Result shows that from the aspect of financial cost, economic benefits of three eco-campus modes are insignificant. Both ecological benefits and economic benefits are achieved at the same time. According to the overall evaluation results of Principal Component Projection Model, the "Pig, Toilet – Biogas – Vegetable" mode has obtained the maximum economic benefits, followed by the "Grass – Sheep, Toilet – Biogas – Fruit". And the "Toilet – Biogas – Vegetable" has the poorest economic benefit. This result is of strong practical significance and provides a theoretical basis for economic evaluation research and extension of eco-campus construction in rural primary and secondary schools in other areas of China.

Key words Rural eco-campus; Economic benefits; Evaluation; Principal Component Projection; China

Northwest China is mostly arid and semi-arid, having fragile and unstable ecosystem[1-2]. Under the great challenge of agricultural resource and environmental issues, economic development and ecological issues[3], Northwest Rural Eco-campus Model is combined with the circular economy idea and the large-scale efficient biogas project, making full use of the modern biotechnology transformation and the waste resources of schools. This has far-reaching significance for saving energy, making waste profitable, producing clean energy, producing considerable economic benefits, and improving environment of rural primary and secondary schools in northwest China.

Researches on northwest rural Eco-campus mainly focus on improving the health status of the school toilets, making waste profitable, and improving dining environment for teachers and students. Few scholars pay attention to the theory and method research on the economic evaluation of "Eco-campus" model. Northwest Rural Eco-campus Model refers to the circular economy model of "Grass-Sheep, Toilet – Biogas – Fruit", "Pig, Toilet – Biogas – Vegetable" and "Toilet – Biogas – Vegetable" with biogas project as a link based on the needs and actual situation of schools. By combining the quantitative evaluation and qualitative evaluation together, direct economic benefits, technical and economic benefits, and social and economic benefits status of rural primary and secondary schools are clarified, so that economic evaluation of Northwest Rural Eco-campus Model in rural primary and secondary schools becomes more measurable and operable, offering scientific basis and guidance for the promotion and construction evaluation of Rural Eco-campus Model[3-7]. Starting from the angle of the Principal Component Projection, we discuss the economic evaluation model suitable for Rural Eco-campus Model. Several different modes are used to evaluate the economic benefits of Eco-campus. Ranking result of the economic benefits is obtained by calculating, which is basically consistent with the actual situation.

1 Index selection, data source and research method

1.1 Index selection Economic benefit of rural Eco-campus is chiefly manifested in financial cost benefit, social and economic benefit, technical and economic benefit and ecological and economic benefit. Therefore, they are selected as the four indices.

1.1.1 Index of financial cost benefit. It includes three sub-indices of investment yield, financial net present value, and benefit-cost ratio. Investment yield reflects the economic benefits of the implementation of the project, which is the ratio of project output to project input. Financial net present value PNPV = (*CI*

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$-CO)_t(Hic)^{-t}$, where $(C-CO)_t$ is the net cash flow at the seventh year, H is calculation period of project, and ic is standard discount rate. Benefit-cost ratio reflects of the ratio of total revenue to total cost.

1.1.2 Index of social and economic benefit. It includes two indices of the saving rate of medical cost and the average increasing rate of households after training. Saving rate of medical cost (%) = (Routine medical expense before the implementation of project − Routine medical expense after the implementation of project)/Routine medical expense before the implementation of project × 100. Average increasing rate of households after training (%) = (Average annual income and cost saving after the implementation of project)/ Average annual income before the implementation of project × 100.

1.1.3 Index of technical and economic benefit. It includes four indices of the water saving of toilet flushing, decreasing rate of pests, increasing rate of fruit (vegetable) industry, and increasing rate of technical skills. Water saving of toilet flushing (%) = (Unit water price × Measuring time of the year × Pump flow × Flushing frequency × Flushing duration each time)/Investment fund of project construction × 100. Decreasing rate of pests (%) = (Pets frequency before the implementation of project − Pets frequency after the implementation of project) × 100. Increasing rate of fruit (vegetable) industry = Fruit or vegetable income after the implementation of project − Fruit or vegetable income before the implementation of project) × 100. Increasing rate of technical skills is classified into five grades according to the evaluation on enhance level of technical skills.

1.1.4 Index of ecological and economic benefit. It includes five indices of the saving rate of afforestation cost, reduction rate of CO_2, reduction rate of SO_2, soil improvement, and fertilizer saving rate. Saving rate of afforestation cost (%) = Afforestation cost of the saved fuelwood/Investment funds of project construction × 100. Reduction rate of CO_2 = (CO_2 emission from coal − CO_2 emission from biogas)/CO_2 emission from coal × 100. Reduction rate of SO_2 = (SO_2 emission from coal − SO_2 emission from biogas)/SO_2 emission from coal × 100. Soil improvement (100%) = (Organic matter content of soil with biogas − Organic matter content of the compared soil)/Organic matter content of soil with biogas × 100. Fertilizer saving rate (100%) = (Unit price of biogas × annual biogas yield)/Investment funds of project construction × 100.

1.2 Data source According to the sample survey of students, the investigation on school finance and surrounding villagers, original survey data of economic benefit in Eco-campus with three different models are obtained (Table 1). Among them, model 1, 2 and 3 are "Grass – Sheep, Toilet – Biogas – Fruit" model, "Pig, Toilet – Biogas – Vegetable" model and "Toilet – Biogas – Vegetable" model, respectively.

Table 1 Original data of economic benefits in northwest rural Eco-campus

Model	Investment rate of return C_1	Financial net present value C_2	Benefit-cost ratio C_3	Water saving of toilet flushing C_4//%	Decreasing rate of pests C_5//%	Increasing rate of fruit and vegetable C_6//%	Increasing rate of technical skills C_7//%
1	0.130	128 600	1.077	1.00	20.00	12.00	30
2	0.144	122 140	1.111	1.36	70	42.85	21
3	0.059	918.02	0.796	0.67	34	53.00	43

Model	Saving rate of medical cost C_8//%	Increasing rate of household income C_9//%	Annual saving rate of afforestation cost C_{10}//%	Reduction rate of CO_2 C_{11}//%	Reduction rate of SO_2 C_{12}//%	Degree of soil improvement C_{13}//%	Fertilizer saving rate C_{14}//%
1	80	7.39	1.60	0.365 6	70.75	70	30
2	81	6.41	13.8	0.315 0	20.88	72	100
3	85	6.34	3.32	0.757 8	50.11	68	70

1.3 Research method Principal Component Projection Evaluation Method is used to assess the economic benefit of northwest rural Eco-campus.

2 Result and analysis

2.1 Matrix elements treatment Due to the diversity of dimensionless in evaluation index, normalization processing of matrix elements in evaluation samples is carried out in order to reduce the irrational and unscientific evaluation. Efficiency Coefficient Method is adopted to conduct normalization processing of index value. Table 2 reports the matrix element after dimensionless treatment.

2.2 Determination of the index weight

2.2.1 Calculation of weight. There are many methods to determine the weight, such as subjective, objective and comprehensive weight methods. Entropy Method is a method to determine the index weight according to the index value of evaluation object, which is more objective and reflects the intercomparison relationship among indices. Therefore, we use Entropy Method to determine the weight of index.

2.2.2 Index weighting. Weight of index is obtained according to the method mentioned above. Weighted processing of sample matrix Y is conducted. Let $z_{ij}=\omega_{ij}y_{ij}$, we have sample matrix $Z=(z_{ij})_{n\times m}$, and evaluation vector $d_i=(z_{i1}, z_{i2}, \cdots, z_{im})$, where $i=1, 2, \cdots, n$.

2.3 Orthogonal transformation of index There are many indices for the economic evaluation of rural Eco-campus, relevant connection between indices will cause overlapping and interaction of evaluation information, so that it is difficult to objectively analyze the relative position of evaluation vector. Orthogonal transformation of index value is carried out in order to filter out the repetitive information of index.

$f_{ij}(i=1,2,3)$ is obtained by using $Y_{17\times3}$ data. We have $ln3=1.099$ and the value of entropy e_j. Finally, each index weight ω is calculated. Table 3 reports the weight parameters of indices.

Table 2 Evaluation sample of economic benefit in northwest rural Eco-campus

Model	Investment rate of return C_1 // %	Financial net present value C_2 // %	Benefit-cost ratio C_3 // %	Water saving of toilet flushing C_4 // %	Decreasing rate of pests C_5 // %	Increasing rate of fruit and vegetable C_6 // %	Increasing rate of technical skills C_7 // %
1	0.835	1.000	0.892	0.478	0.000	0.000 0	0.409 0
2	1.000	0.949	1.000	1.000	1.000	0.752 0	0.000 0
3	0.000	0	0	0	0.280	1.000	1.000 0

Model	Saving rate of medical cost C_8 // %	Increasing rate of household income C_9 // %	Annual saving rate of afforestation cost C_{10} // %	Reduction rate of CO_2 C_{11} // %	Reduction rate of SO_2 C_{12} // %	Degree of soil improvement C_{13} // %	Fertilizer saving rate C_{14} // %
1	0.000 0	1.000 0	0.000 0	0.113 0	0.500	0.500	0.000
2	0.200 0	0.060 0	1.000	0.000	1.000	1.000	1.000
3	1.000 0	0.000 0	0.139	1.000	0.000	0.000	0.571

Table 3 Weight parameters of indices

Code of index	Weight	Code of index	Weight
C_1	0.029 2	C_8	0.000 2
C_2	0.180 4	C_9	0.001 2
C_3	0.004 9	C_{10}	0.071 3
C_4	0.435 4	C_{11}	0.038 3
C_5	0.059 5	C_{12}	0.047 9
C_6	0.065 0	C_{13}	0.000 1
C_7	0.019 5	C_{14}	0.047 0

2.4 Calculation and sorting of sample projection value

A new decision matrix $U=(u_{ij})_{3\times14}$ is obtained after orthogonal transformation of index. Thus, an ideal decision – making program $d^*=(d_1, d_2, \cdots d_n)$ is established. Projection value Di of evaluation sample is obtained according to $d_0^*=1/\|d^*\| \times d$. According to the value of sample projection value, we can calculate and sort the economic benefit status of Eco-campus model (Table 4).

Table 4 Economic benefit evaluation of three kinds of Northwest Rural Eco-campus Models

Model	Evaluation score of Principal Component Analysis D_i	Rank
1	0.185 3	2
2	0.194 5	1
3	0.180 2	3

2.5 Analysis of evaluation result

(1) From the aspect of financial cost analysis, the economic benefits of three Northwest Rural Eco-campus Models are all not extreme significant. However, both ecological benefit and economic benefit are realized. According to the weight, water saving of toilet flushing, financial net present value, annual saving rate of afforestation cost, and increasing rate of fruit and vegetable have relatively great weights, reflecting that the income increasing and cost saving is the major factor of economic benefit of Northwest Rural Eco-campus Model. Besides, decreasing rate of pests, reduction rate of CO_2, and reduction rate of SO_2 also have greater weights, reflecting the indirect economic benefit index. They are important factors of economic benefit in Eco-campus Model. Weight of the seven indices reaches as high as 0.906 5, which plays a decisive role in the evaluation result of economic benefit.

(2) According to the overall evaluation results of Principal Component Projection Model, the " Pig, Toilet – Biogas – Vegetable" mode has obtained the maximum economic benefits, followed by the " Grass – Sheep, Toilet – Biogas – Fruit". And the " Toilet – Biogas – Vegetable" has the poorest economic benefits. This comprehensively reflects the economic benefits of three Northwest Rural Eco-campus Models, which is relatively consistent with the actual situation. There are many reasons for the relatively good economic benefit of " Pig, Toilet – Biogas – Vegetable". And the major reason is the high price of pig, as well as the abundant biogas produced by breeding industry, which saves energy cost and improves the vegetable yield.

3 Discussion

(1) Principal Component Projection Model solves the problem of information duplicate influence among indices in economic benefit evaluation of Northwest Rural Eco-campus Model. Problem of index weight is comprehensively considered. Combining with the objective weighting method, Principal Component Projection Model has more practical evaluation result and greater extended significance.

(2) When evaluating the economic benefits, Principal Component Projection Model regards the evaluation sample as dimensional vector, and projects to the same vector, so as to obtain the projection value of sample and to accurately reflect the proximity of evaluation sample and ideal sample.

(3) Case analysis shows that Principal Component Projection Model has strong feasibility when evaluating the economic benefits of Northwest Rural Eco-campus Model. Evaluation result is of certain practical significance and provides basis for decision making of economic benefit evaluation of other Rural Eco-campus Mode.

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基于主成分投影模型的西北农村生态校园经济效益评价及应用

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摘要 选取财务成本效益(投资收益率、财务净现值、益本比)、社会经济效益(医疗费用节省率和培训过的农民户均增收率)、技术经济效益(冲厕节水率、病虫害减少率、果业或蔬菜增收率和工人技术水平提高率)和生态经济效益(造林费用节省率、CO_2 减排率、SO_2 减排率、土壤改良、化肥节约率)共4个1级指标14个2级指标,依据3种不同模式生态校园的经济效益的原始调查数据,利用主成分投影评价法,采用功效系数变换法对指标值进行归一化处理,在将矩阵元素进行无量纲化处理的基础上,探讨了我国西北农村生态校园模式经济效益评价指标权重的计算方法,建立了生态校园经济效益评价的主成分投影评价模型。结果表明,从财务成本的角度来说,3种生态校园模式的经济效益并不是很显著,在实现生态效益的同时也实现了其经济效益;从主成分投影评价模型的总体评价结果来看,猪、厕-沼-菜模式整体经济效益最佳,草-羊、厕-沼-果次之,厕-沼-菜最差,具有的较强实际意义,为全国其他地区农村中小学进行生态校园建设的经济效益评价研究和推广提供理论基础。
关键词 农村生态校园;经济效益;评价;主成分投影

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北京市经济水平统计分析

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摘要 依据1995~2007年北京市经济发展的相关数据,选取相关经济指标,采用主成分分析法对1995~2007年北京市经济发展水平进行分析。结果表明,1995~2007年国民经济保持高速、持续、稳定的发展,第一、二产业产值均逐年递增,第三产业产值增长迅猛;年生产总值、第三产业总产值和社会消费品零售总额对北京市经济水平情况影响最大,第二产业总产值是北京市经济环境中的增长能力因子。通过实证分析发现,在经济高速发展的同时,北京市经济发展过程中存在着自然资源匮乏、城市规模发展过快、城市污染严重、缺乏对周边地区的辐射能力、产业结构不合理这一系列问题,为此,有针对性地提出强化全国政治中心、文化中心功能、加强北京基础设施建设、完善社会保障体系、提升产业竞争力、抢占科技前沿和产业链的高端等对策建议,以期加快北京经济发展,完善相关制度和政策,为政府制定相关政策提供依据。
关键词 经济水平;主成分分析;SPSS统计软件