Evaluation for Applied Materials of Eco-technology

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Abstract: The eco-materials (include natural and artificial material) applied in the eco-technology in internal currently, usually lack of evaluation for applicative conditions. Hence, this study carry on the whole research and identifications to draft the eco-materials of eco-technology. The evaluation models of applied materials for eco-technology were proposed. The quantitative score were obtained by expert's person evaluation. Three models were proposed to quantify the effects of applied materials on the ecological environment. The statistical procedures were adopted to compare the performance of these materials for eco-technology. The results indicated that the comparison of applied materials can be treated by quantitative analysis. For the further analysis, more evaluated data from expert's experience need to be collected then the bias of person subject can be reduced. In addition to reach the benefits in the respects of ecosystem, society, economy and function, also practice the comprehensive effects in eco-technology.

Key words: landscape materials; eco-technology; evaluation models; life cycle assessment(LCA)

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1 Introduction

The Taiwan government strongly pushes the eco-technology in recent years, use the natural building materials, such as native stone, soil and applicative plant, to avoid to break the local ecosystem environment. However, partial engineering structures still need the concert usage of other natural or the artificial materials, to reach the target of looking after both sides of the engineering security and biodiversities. The preservation work of soil and water has a long history in Taiwan. The traditional way is to apply the solid construction to protect the environment, such as concrete materials. The effect of theses constructions on the ecological environment was neglected in the past. Recently, maintain and recovery of natural environment has been emphasized. The eco-technology then be received the attention by public. Many construction cases had executed. The applied materials of eco-technology are diverse. The selection of these materials for the construction of eco-technology need to be studied. In this study, the evaluation models of applied materials for eco-technology were proposed. The quantitative score were obtained by expert's person evaluation. The statistical procedures were adopted to compare the performance of applied materials for eco-technology.

2 The Evaluation Characteristics of Applied Materials

The basic requirement for applied materials of eco-technology is the criteria of Tri "E", that is, efficiency, economical, and environment. The meaning of "Efficiency" is that these materials can be used to resist the stress of disasters. The meaning of "Economic" is that the cost of these materials can be accepted by users. The meaning of "Environment" is that these materials can be used to maintain the diversity of ecology. There are four functions to serve as the standard to evaluate the performance of materials. The evaluation characteristics for applied materials are introduced as follows:

2.1 Safety Function evaluation

The basic requirement for the soil and water conservation is the safety function. So the selection of the applied materials has to consider the ability to resist the disaster. The evaluation items for safety function of applied materials are the strength ness, endurance, water permittivity, stability of slope land, the working flexibility for different regions, and the possible of environmental destroy at the installing stages.

2.2 Ecological habitat function

The requirement of applied materials for the ecological habitat is to maintain the biological diversity. So the evaluation items included the diversity of biology, plant vegetation ability, and animal habitats conservation.

2.3 Economical function

The characteristics of economical function are to reduce the construct cost and maintain cost. The evaluation items included the unit cost of materials, the require working hours, and the depression periods of materials.

2.4 Sustainable function

To meet the requirement of natural conservation, the ratio of application of the natural materials need to be increased. The reuse or recycle of materials is encouraged. The evaluations items included the reuse ability of materials, the energy requirement at the produced process,

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the adding waste in the manufacturing process, the effect on the natural environment at the destroying or dissemble process, and the effect of natural environment during the natural dissemble process.

3 The Evaluation Model

There were some models adopted by civil or environment engineers to evaluate the cost or the effect of construction materials on ecology. However, these models did not consider the characteristics of applied materials of eco-technology. These models can not be applied directly. There are four evaluation models for applied materials proposed in this study:

(1) Performance evaluation model

(2) Ecological characteristics evaluation model

(3) Life cycle assessment evaluation model

(4) Integrated evaluation model

3.1 The performance evaluation model

This model provides the basic information of applied materials. The characteristics of efficiency and economical are considered in this model. The typical survey is showed in Table 1.

3.2 The ecological characteristics evaluation model

The emphasizing points for ecological consideration of applied materials are maintaining of the living habitats and ecological diversity. The impact evaluating values are: 2 = good performance, 1 = medium performance, 0 = none. The raw data of ecological performance are evaluated by author. Then these scopes are further analyzed. As the statistical method of evaluation model was finished. The survey tables will be evaluated by experts. The final evaluation results were estimated by these data. The typical ecological evaluation table is listed in Table 2a and 2b.

3.3 The life cycle assemble evaluation model

The applied materials of eco-technology not only had the strength to resist the external stress, but also had the ability to protect the natural environment. The life cycle assessment (LCA) model is adopted to evaluate the ecological characteristics of applied materials. The special characteristics for the LCA models are to consider all process units. The effects of production, utilization, decay, reused units on the environment pressure are estimated. According to the ISO14040, the evaluation table was proposed as Table 3a and 3b. The input and output items included air pollution, water pollution, soil pollution, materials consumptions, energy consumption, and the production of final wastes. There are five grades for evaluating score: 5= no influence, 3= light, 2= medium, 1= severe, and 0 = very severe.

3.4 Integration evaluation model

In this evaluation process, these materials are evaluated by its characteristic of function, ecology, economic and reused or recycle ability. There are five grades for estimation score: 5= prior to apply, 4= good to apply, 3 = can be applied, 2 = be applied with reluctantly, 1 = cannot be adopted. The typical evaluation results are listed in Table 4.

Table 1 The performance information for applied materials of eco-technology

Materials item	Names	Working conditions: Flow speed/(m·s^{-1}) Slope above 1/1.5	Working conditions: Flow speed/(m·s^{-1}) Slope below 1/1.5	Estimated units purchase cost (NT)	Maintain units cost	Operation conditions	Applied period
Nature stone	stone		1~8	350		Natural stone available	20
Concretes	Concretes		1~8	350		Fitting local conditions	20
Woods	Woods	1~4		423		Artificial channel	5
Wire	Vegetative	1~5		1100		Artificial channel	7
cylinder	Multilayer	1~7		750		Can not be applied at high acid or salt soil	7
	Pores concretes block	1~8		1070		Fitting local conditions	20
Others	Vegetable-concretes	1~8		1570			10

Note: The purchase units cost is the estimated cost. These units cost is varied with the economical and social conditions.

Table 2a The ecological evaluation values of applied materials

Evaluation items	Biological materials: Woods	Biological materials: Artificial wood	Biological materials: Vegetables stake	Biological materials: Plants for embankment	Other materials: Moss	Other materials: Bark manual	Other materials: Wood fiber	Other materials: Soil bags
Support the continuous ecological environment	0	0	2	2	1	2	2	1
Support the special ecological environment	0	0	2	2	1	2	2	1
Support the diversity environment	1	0	2	2	1	2	2	1
Support the vegetative environment	0	0	2	2	2	2	2	1
Help to produce the vegetative environment	1	0	2	1	2	1	2	1
Porous surface	1	1	2	2	2	2	2	2
Roughness surface	1	1	2	2	2	2	2	2
Natural material	1	1	2	2	1	2	2	1
Localized materials	1	0	1	1	0	1	1	1
Penetration of materials	0	0	1	1	1	1	1	2
Water purified ability	0	0	1	2	1	1	1	1
Adopted ability of local surface	1	1	2	1	2	1	2	1
Preservation and applied of surface soil at working	1	1	2	2	2	2	2	2
Total scores	8	5	23	22	18	21	23	17
EEC index/%	30.7	19.2	88.5	84.6	69.2	80.8	88.5	65.4

Table 2b The ecological evaluation values of applied materials

Evaluation items	Complex molecular compound	Natural stone	concrete	Square vegetable block	Hexagon stone block	Flower stone	Green harmoney	Bio grass
Support the continuous ecological environment	1	1	1	1	2	1	1	1
Support the special ecological environment	1	1	1	1	2	1	1	1
Support the diversity environment	1	1	1	1	1	1	2	2
Support the vegetative environment	0	0	0	1	1	1	2	2
Help to produce the vegetative environment	0	0	1	1	1	1	2	2
Porous surface	0	0	1	2	2	1	2	2
Roughness surface	0	1	1	2	2	1	2	2
Natural material	0	2	0	0	0	0	0	0
Localized materials	0	1	0	0	0	0	0	0
Penetration of materials	0	0	0	1	1	1	1	2
Water purified ability	1	0	0	1	1	1	1	1
Adopted surface ability	1	1	1	1	1	1	1	1
Preservation and applied of surface soil at working	1	1	1	1	1	1	1	1
Total scores	7	9	8	13	15	11	16	17
EEC index/%	26.9	34.6	30.7	50	57.4	42.3	61.5	65.4

Table 3a The life cycle assemble evaluation of applied materials

Name	items	Materials collection	Material treatment	produced	assemble	transpiration	utilization	Recycle and disassemble	Waste collection	Totals cores	EEC index
Wood	Air pollution	5	5	5	5	5	5	5	5	40	88.3
	Water	5	5	5	5	5	5	5	5	40	
	Soil	5	5	5	5	5	5	5	5	40	
	Material consumption	3	5	3	5	3	5	5	3	32	
	Energy	3	3	3	3	3	3	3	3	24	
	Final wastes	5	3	3	5	5	5	5	5	36	
Artificial woods	Air pollution	3	5	5	3	3	5	3	3	30	68.8
	Water	5	5	5	5	5	5	5	5	40	
	Soil	3	3	3	3	3	3	3	3	24	
	Material consumption	3	3	3	3	3	3	3	3	24	
	Energy	3	2	2	2	3	3	3	3	23	
	Final wastes	3	3	3	3	3	3	3	3	24	
Vegetable stake	Air pollution	5	5	5	5	3	5	5	5	37	90.4
	Water	5	5	5	5	3	5	5	5	37	
	Soil	5	5	5	5	3	5	5	5	37	
	Material consumption	5	5	5	5	3	5	5	5	37	
	Energy	3	3	3	5	3	5	5	5	32	
	Final wastes	5	5	5	5	3	5	5	5	37	

Table 3b The life cycle assemble evaluation of applied materials

Name	items	Materials collection	Material treatment	produced	assemble	transpiration	utilization	Recycle and disassemble	Waste collection	Totals cores	EEC index
Plants for embankment	Air pollution	5	5	5	5	3	5	5	5	38	92.5
	Water	5	5	5	5	3	5	5	5	38	
	Soil	5	5	5	5	3	5	5	5	38	
	Material consumption	5	5	5	5	3	5	5	5	38	
	Energy	3	3	3	5	3	5	5	5	32	
	Final wastes	5	5	5	5	3	5	5	5	38	
Higher molecular compound	Air pollution	5	3	3	5	5	5	5	5	36	78.8
	Water	5	5	5	5	5	5	5	5	40	
	Soil	5	5	5	5	5	5	3	1	34	
	Material consumption	3	3	2	3	5	5	5	5	31	
	Energy	3	2	0	2	3	3	3	3	19	
	Final wastes	3	0	3	5	3	5	5	5	29	
stones	Air pollution	3	3	3	3	3	3	3	3	24	71.7
	Water	5	3	3	5	5	5	5	5	36	
	Soil	3	3	3	5	5	5	5	5	34	
	Material consumption	3	2	2	2	3	3	3	3	21	
	Energy	3	2	2	3	2	3	3	5	23	
	Final wastes	3	3	5	5	3	5	5	5	34	

Table 4 The integration evaluation of applied materials

Characteristics	Evaluation items	Woods	Artificial woods	Vegetable stake	Woods fiber	Higher molecular compound	Square vegetative block	Biograss	Non woven	Landlok TRM
Function	Strength	3	4	2	1	3	5	4	4	2
	Endurance	3	5	2	1	3	5	4	4	2
	Water permitivity	3	5	4	4	4	5	4	5	5
	Slope stability	3	5	5	1	3	5	3	5	5
	Flexible of working	3	5	5	5	4	4	3	5	5
	Environment destroy	3	5	5	5	2	4	4	5	5
	Subtotal	18	24	23	17	19	28	22	28	24
Ecology	Animal conservation	3	2	5	3	1	3	4	3	2
	Plant vegetation	4	3	5	5	1	4	5	3	5
	Living diversity	4	3	5	3	1	4	5	3	3
	Subtotal	11	8	15	11	3	11	14	9	10
Economic	Unit cost	5	2	4	3	3	3	4	3	3
	Assemble/disassemble of model	5	5	5	5	3	2	3	5	5
	Easy degree of working	3	5	4	5	3	1	1	2	4
	Required tune if working	4	5	4	5	3	1	1	3	4
	Reused times	3	5	4	1	3	1	1	1	1
	Easy degree of maintain	3	3	3	5	3	4	4	3	2
	Subtotal	23	25	24	24	18	12	14	17	19
Reuse or recycle	Reuse or recycle	3	3	5	1	2	2	3	1	1
	Energy consumption	1	3	5	3	1	2	2	3	2
	Waste production	2	2	5	5	2	2	2	2	4
	Environment impact during destroy	5	5	5	5	5	3	3	2	4
	Environment impact of dissemble	5	2	5	5	5	3	3	2	4
	Subtotal	16	15	25	19	15	12	13	10	15
Characteristics	IEI value	8.23	9.59	16.28	10.90	5.49	8.45	9.61	8.56	8.90

4 The Statistical Technique of Evaluation Model

There are four evaluation tables used in this study. The performance evaluation model was used to provide the basic information of applied materials. Others models are used to compare the fitting of eco-technology. The primary statistical technique for others three models are introduced:

4.1 The ecological characteristics evaluation model

The total score of each applied material is served as the standard for comparison. The EEC index was defined as:

$$EEC = \text{Total scores}/\text{full scores} = \text{Total}/26 \quad (1)$$

4.2 The ecological characteristics evaluation model

For each material, there are six items and eight unit processes (y_i). The data structure is a 6×8 matrix (x_i). The ECE scores (ecological characteristics evaluation scores) was defined as:

$$\text{ECE scores} = \sum_{i=1}^{6}\sum_{i=1}^{8} x_{ji} \quad (2)$$

The full score is 240($6\times 8\times 5$). The ECE index was defined

$$\text{ECE index} = \text{ECE scores}/240 \quad (3)$$

The ECE index was served as the criterion to evaluate the ecological function of materials.

4.3 The integral evaluation model

The integral evaluation model included four main criteria of applied materials: function, ecological, economic, reuse and recycle. The original scores were noted as x_i = function, y_i = ecological, z_i = economic, w_i = reuse and recycle. Because the numbers of each item was different, the ratio of each item was defined as following.

$$R_x = \sum_{i=1}^{6} x_i/30 \quad (4)$$

$$R_y = \sum_{i=1}^{3} y_i/15 \quad (5)$$

$$R_z = \sum_{i=1}^{6} z_i/30 \quad (6)$$

$$R_w = \sum_{i=1}^{5} w_i/25 \quad (7)$$

The integral evaluation index (IEI) then be calculated by its weights coefficient,

$$IEI = W_x\cdot R_x + W_y\cdot R_y + W_c\cdot R_2 + W_d\cdot R_w \quad (8)$$

The weights coefficient is defined as follows:

$$W_i = 0, \text{if} \quad 0\le R_i\le 25\% \quad (9)$$

$$W_i = 1, \text{if} \quad 26\le R_i\le 50\% \quad (10)$$

$$W_i = 3, \text{if} \quad 51\le R_i\le 70\% \quad (11)$$

$$W_i = 4, \text{if} \quad 71\le R_i\le 85\% \quad (12)$$

$$W_i = 5, \text{if} \quad 86\le R_i\le 100\% \quad (13)$$

4.4 The correlation analysis

The index of EEC, ECE, and IEI then were further analyzed by correlation analysis.

5 Results and Discussion

The typical EEC index for the ecological characteristics evaluation model is listed in Table 2a and 2b. Biological materials or natural materials have the higher EEC index than that of others materials. This evaluation results is reasonable for qualitative analysis. However, the quantitative analysis needs to be further study with more data from experts. The typical ECE scores of the life cycle assemble

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54.3%、全钾15.7%、全磷5.7%、速效氮105.9%、速效磷33.2%。林草兼作,若种苜蓿,2年后与无草林地相比,土壤有机质增加76%,有效氮增长5.9倍,速效磷增长2.3倍,速效钾增长3倍,从而使草地林的树径增长48%,树冠增长29%[3];种植牧草尤其是多年生牧草,由于增加地表覆盖率,减少冬春季土地裸露,且由于根系发达,表现出良好的固土效果,有利于改善生态环境。

近两年来,本溪、抚顺等地区已经在退耕地上种植了紫花苜蓿,成效十分显著。但退耕还林还草,一方面要提倡合理规划、规模种植,另一方面还必须强调因地制宜,宜草则草、宜林则林。

3.5 合理配方,科学管理

辽东山区舍饲期间的主要饲草是秸秆饲料。秸秆是一种粗饲料,特点是粗纤维含量高(30%～40%),并含有木质素。木质素虽然能够为牛、羊等反刍动物吸收利用,但由于秸秆终归属于劣质粗饲料,所以,为了保证绒山羊的正常发育,获得满意的绒山羊产品,必须在日粮中配以优质青干草,并适量补充精料、氮素、矿物质和维生素等。表1是辽宁绒山羊原种场研究制定的辽宁绒山羊在全舍饲状态下各类羊只的每日饲喂定额,可作为辽东山区饲养绒山羊的日粮标准。

另外,舍饲圈养绒山羊加强日常管理也是非常必要的。羊舍的设计要科学,避风向阳,要有运动场,让羊适当运动,尤其母羊要增加运动量。要保持羊舍干燥。舍饲食槽数量要充足,设计应科学,防止羊只争食顶撞。每天定时饮水,要饮清洁水。及时补盐,每周喂盐3次。春、秋季搞好驱虫和药浴。秋季(9～10月)大、小羊只都要注射"羊三联"或"四联"疫苗,防止发生传染病。放牧期间,羊群不易大,根据辽东山区牧草地现状,放牧羊群一般30～50只一群为宜。

表1 辽宁绒山羊原种场在全舍饲状态下各类羊只的每日饲喂定额 g

类 别	精 料	青贮料	青干草
种公羊	1250	1750	500
成年母羊	350	1500	500
育成母羊	300	1000	300
育成公羊	350	750	250
羔 羊	200	350	150

4 结 语

绒山羊从传统的放牧方式转变为舍饲圈养是一种新生事物,其效果如何需要实践的检验,饲养模式应该追随科学研究的成果,随着科学研究的进展而日臻完善。绒山羊舍饲圈养技术成功,将为水土保持生态自我修复工程的实施予以极大的支持,因为实现水土保持生态自我修复的目标必然要以稳定并提高山区人民的经济收入为前提。

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evaluation is listed in Table 3a and 3b. The natural plants used for protected have the highest score. Stone materials have the lower scores among the six types of materials. The IEI values of the integral evaluation of applied materials are listed in Table 4. The IEI value of wood materials is calculated by the following:

For Vegetable stake, $x_i = 23$, $y_i = 15$, $z_i = 24$, $w_i = 25$, then

$R_x = 0.77$, $R_y = 1.00$, $R_z = 0.80$, $R_w = 1.00$

From equation (9) to equation (13),

$W_x = 4$, $W_y = 5$, $W_z = 4$, $W_w = 5$,

IEI = $0.77 \times 4 + 1.00 \times 5 + 0.80 \times 4 + 1.00 \times 5 = 16.28$

In Table 4, vegetative stake has the highest IEI values and higher molecular compound material has the lowest value.

From the above discussion, the comparison of applied materials can be treated by quantitative analysis. For the further analysis, more evaluated data from expert's experience need to be collected then the bias of person subject can be reduced.

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