Network Design and Simulation of Guangxi WEEE of the Reverse Logistics

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Abstract

With the rapid development of electronic industry, how to effectively recycle and deal with the increasing waste electrical and electronic equipment (WEEE) has attracted great attention. In the process of e-waste resource utilization, the construction of reverse logistics system network is a key link to generate economies of scale. According to the structure of the recycling network, the reverse logistics network of electronic waste is divided into three stages: recovery point-transit warehouse, transit warehouse-treatment center, and disposal center-landfill site. Considering the reality comprehensively, the first stage network model is constructed by using quantitative method, and the second and third stages network model is constructed by combining quantitative and qualitative method. And use Flexsim simulation software to simulate, the results of Guangxi electronic waste reverse logistics network design provides a basis.

Keywords

Waste electrical and electronic equipment (WEEE),reverse logistics system,network design, Flexsim simulation.

1. Introduction

Improper recycling and disposal of waste will pollute the environment, threaten the safety of human life, and produce serious waste of renewable resources, such as laboratory waste, nuclear power plant waste, medical waste and electronic waste (WEEE), etc. Among them, WEEE mostly comes from the daily life of residents, which has problems such as difficulty in recycling, uncertain amount of recycling and unscientific way of recycling treatment. In order to protect the natural environment, make full use of resources, and promote the realization of circular economy and sustainable development, various provinces and cities in China are actively exploring the construction of electronic waste reverse logistics network. In the early stage, the design of WEEE reverse logistics network was mainly classified by qualitative methods. Then, considering the uncertainty of WEEE reverse logistics recovery, it began to comprehensively use various quantitative models to design the network. Such as Zhou[1], Bigum et al. [2], Krikke et al. [3], Kara et al. [4], Pishvae et al. [5], Ramezanian[6], Achillas et al. [7], Patroklos et al. [8], and Shokohyar[9] and Vahdani[10] respectively established a multi-objective linear programming model for WEEE reverse logistics with optimal economic and environmental benefits, considering the uncertainty of demand and recovery, and conducted an example analysis to verify the feasibility of the model. Patroklos et al. [8] used the system dynamics simulation method to analyze the parameters such as recovery amount, recovery and remanufacturing rate, and environmental impact degree, and studied the disturbance problem of WEEE reverse logistics network.In domestic literature, when studying the design of WEEE reverse logistics network, the target is usually the optimal cost or the maximum profit, and the modeling methods are mostly fuzzy programming, linear programming, nonlinear programming and so on. For example, Qiu Jianwei et al. [11] used fuzzy parameters to describe the uncertain amount of recycling and used fuzzy programming method to figure out the network layout of Guangxi electronic waste reverse logistics. Gui Yunmiao et al. [12], Wu Xinghua et al. [13], Jiang Bing et al. [14] set up a mixed integer nonlinear programming model for multi-cycle forward and reverse logistics integrated operation with the objective of cost optimization, considering the uncertainty of recovery quantity. Chen Yong et al. [15] set up a multi-cycle and multi-objective reverse logistics network model with profit maximization as the goal. Zhou Xianghong et al. [16] set up a multi-period and multi-objective dynamic mixed integer programming model with the influence of government behavior on reverse logistics as the parameter and social benefit and recovery economic benefit as the target. Mao Haijun et al. [17], based on the uncertainty of market demand and product recovery, constructed a stochastic chance constrained programming model with optimal cost, and solved the model with hybrid intelligent algorithm. Liu Zhifeng et al. [18] and Zhu Haibo [19] built forward and reverse logistics network closed-loop supply chain multi-objective programming model considering the randomness of product recovery quantity, quality and product remanufacturing rate, and verified the effectiveness of the model through numerical examples. Most of the above literatures consider qualitative and quantitative methods separately, and the results of quantitative calculation are usually only theoretical spatial positions, which may not be consistent with the reality. This paper considers that it is not appropriate to only consider the principle of the lowest cost in the practical operation of the design of the electronic waste recycling logistics network in a region. Other principles, such as environmental protection principle, forward-looking principle and operational principle, should also be considered comprehensively. Therefore, this paper will use quantitative and qualitative methods to further study the Guangxi electronic waste reverse logistics system network.

2. E-waste reverse logistics system network stage model

2.1. Stage 1: Recycling-transit warehouse network model construction

2.1.1. Problem description

In a logistics network with one node, each node may be the starting point or end point of goods. The flux of goods from the origin to the destination through several nodes is called OD quantity, and the node chain through is called OD flow. According to the network organization mode of multi-hub station single distribution of axial amplitude, each OD flow is required to converge at one or two hub stations before arriving at the destination. Because the transportation between the hub stations is the main line transportation, it has the scale economy, thus saving the logistics cost of the whole system. The problem is how to choose one node from the nodes as the pivot point so as to minimize the logistics cost of the whole network. This problem is also called p-hub location problem.

2.1.2. Model building

N :The set of all nodes in a network;

H :The set of all potential hub points in the network, $H \subseteq N$;

i, j :The place of origin and destination, $i, j \in N$;

k, m :Candidate hub point, $k, m \in H$;

p :Set to the number of hub points;

W_{ij} :OD amount from node $i \in N$ to node $j \in N$;

C_{ij} :Unit transport cost from node $i \in N$ to node $j \in N$;

α :Discount rate of trunk transportation between hub points;

F_{ijkm} :The total cost of cargo transportation OD flow paths through (i, j) and (i, k, m, j) ;

X_{ijkm} :0-1decision variable,When the value is 1,the path (i, k, m, j) is selected as the path of OD (i, j) stream,means that the goods pass through the hub point i and arrive at the node j from the node k and m. When the value is 0, it means that this path is not selected.

Z_{ik} :0/1 decision variable. When the value is 1, it means that the node $i \in N$ is connected to the hub point $k \in N$;

Z_{kk} :0/1 decision variable. When the value is 1, it means the node is a hub point。

Since trunk lines are used for transportation, the total cost of transportation of goods through the OD flow (i, j) path (i, k, m, j) consists of three parts: Transportation cost from node i to hub, transportation cost of trunk line with discount between hub points and transportation cost from hub to node j ,which is $F_{ijkm} = W_{ij}(C_{ik} + \alpha C_{km} + C_{mj})$, When the node i and j one or both of the nodes are selected as the hub point, the formula for the total cost of goods transportation also holds because of $C_{kk} = 0, C_{mm} = 0$. The mathematical model of the site selection problem of multi-hub single-assignment axis-amplitude network can be expressed as follows:

$$\min \sum_{i} \sum_{j \neq i} \sum_{k} \sum_{m} F_{ijkm} X_{ijkm} \tag{1}$$

$$\text{s.t.} \sum_{k} Z_{ik} = 1 \quad \forall i, \tag{2}$$

$$Z_{ik} \le Z_{kk} \quad \forall i, k, \tag{3}$$

$$\sum_{k} Z_{kk} = p, \tag{4}$$

$$\sum_{m} X_{ijkm} = Z_{ik} \quad \forall k, i, j \neq i, \tag{5}$$

$$\sum_{k} X_{ijkm} = Z_{jm} \quad \forall m, i, j \neq i, \tag{6}$$

$$X_{ijkm},\ Z_{ik} \in \{0, 1\} \quad \forall i, j \neq i, k, m$$

$$i, j, k, m \in N$$

Equation (1) is the objective function, representing the lowest total cost of transportation of all OD flows according to the selected path; Equation (2) guarantees that each non-hub node can only connect with one hub node, that is, the nature of single dispatch; Equation (3) indicates that if a node is not selected as a hub node, then non-hub nodes cannot be connected to it. In other words, when Z_{kk} is zero, Z_{ik} can only be zero；Equation (4) represents the total number of selected hub nodes is p ; Equations (5) and (6) represent any OD stream covering a hub node (k, m) pair. Its starting place i and destination must be connected to the hub point k, m respectively. That is to say, if the starting place is not connected to a hub point k, any path covering the hub point k in the OD stream (i, j) will not be selected, and the same applies to the destination j. This model is an integer programming model.

2.2. The second and third stages: network model analysis of transit warehouse - treatment center - landfill site

On the basis of the solution of the first stage, the network of transit warehouse - treatment center - landfill site is constructed. There are several cases that need to be considered. The first scenario is to transfer the warehouse, processing center, and landfill to the same node (which can significantly reduce transportation costs).The second case is to consider whether the special environment of the node city is suitable for the disposal center and landfill site. Considering the above situation, the method of combining quantitative analysis and qualitative analysis is adopted to construct the second and third stage network.

3. Estimation of electronic waste production in Guangxi

There are many types of electronic waste. This paper selectively conducts statistical research on several commonly used household appliances and electronic and electrical products. That is, TV sets, refrigerators, washing machines, household air conditioners and computers.

3.1. Background of Guangxi

Guangxi has jurisdiction over 14 cities with a total population of about 56.95 million, among which the urban population is about 25.34 million, accounting for 51.09% of the total. The number of permanent resident population in cities of Guangxi District is shown in Table 1.

Table 1: Population of permanent residents in cities of Guangxi District
(Unit: 10,000 people)

city	Nan ning	Liu zhou	Gui lin	Wu zhou	Bei hai	Qin zhou	Fang cheng	Gui gang	Yu lin	Bai se	He zhou	He chi	Lai bin	Chong zuo	A combind
population	734	404	511	307	168	330	96	440	587	366	208	356	223	209	4939

Source: Statistical Bulletin of National Economic and Social Development of Guangxi Autonomous Region, 2020

Since the central government proposed to strengthen the development of the Beibu Gulf Economic Zone, the Guangxi government has strengthened the regional traffic construction and expanded the comprehensive traffic scale. Significant progress has been made in railway and highway construction. The highway odometer of major cities in Guangxi is shown in Table 2.

Table 2: Highway odometer of main cities in Guangxi
(Unit: km)

area	Nan ning	Liu zhou	Gui lin	He zhou	Wu zhou	Lai bin	He chi	Gui gang	Yu lin	Bai se	Chong zuo	Qin zhou	Bei hai
Liuzhou	262												
Guilin	507	245											
Hezhou	565	303	218										
Wuzhou	403	466	381	168									
Laibin	181	81	326	384	385								
Hechi	298	195	343	498	554	276							
Guigang	182	190	436	389	221	109	333						
Yulin	270	282	527	385	217	201	424	92					
Baise	266	516	664	819	669	447	331	448	536				
Chong zuo	159	421	666	724	562	340	457	341	429	385			
Qinzhou	117	379	620	614	446	298	415	225	332	383	235		
Beihai	215	409	654	648	480	328	513	259	232	481	335	100	
Fang chenggang	178	440	681	675	507	359	476	286	393	444	256	61	161

Data source: "China Provincial Highway Series. Guangxi Zhuang Autonomous Region "(Star Map Publishing House, 2007,03)

3.1.1. Sales volume and ownership of major electronic products in Guangxi

Owning amount of electronic products is the premise of estimating electronic waste production. By consulting the Guangxi Statistical Yearbook data (2010-2020), the sales volume and ownership of major electronic products in Guangxi in recent years can be obtained, as shown in Table 3-5.

Table 3: Sales volume of various electronic products in Guangxi from 2010 to 2020 (Unit: 10,000 units)

year	Color TV	washing machine	air conditioner	The refrigerator	computer
2010	50.67	35.84	35.43	31.67	40.90
2011	52.89	34.13	34.36	29.60	42.69
2012	54.15	38.45	36.50	34.46	47.72
2013	55.35	40.07	39.27	35.51	54.26
2014	56.12	41.59	40.51	33.24	55.76
2015	61.23	39.05	38.79	34.39	58.77
2016	65.65	45.91	37.13	35.87	61.64
2017	70.93	44.67	37.71	38.97	62.01
2018	71.20	43.11	36.18	33.82	68.54
2019	69.81	46.36	38.57	34.23	70.89
2020	70.58	40.69	39.48	32.47	72.65

Table 4: Main electronic products ownership per 100 Towner households in Guangxi from 2010 to 2020 (Unit: 10,000 units)

year	Color TV	washing machine	air conditioner	The refrigerator	computer
2010	66.86	50.86	34.28	40.54	40.79
2011	67.89	51.13	34.36	41.60	41.69
2012	65.15	51.45	36.50	42.46	41.72
2013	67.35	51.07	39.27	42.51	42.26
2014	66.12	52.59	40.51	47.24	47.76
2015	70.23	55.05	42.79	48.39	46.77
2016	75.65	58.91	43.13	50.87	50.64
2017	76.93	60.67	47.71	50.97	51.01
2018	76.20	62.11	50.18	53.82	60.54
2019	77.81	64.36	51.57	54.23	66.89
2020	80.58	65.69	53.48	55.47	70.65

Table 5: Average Ownership of Durable Consumer Goods per 100 Rural Residents Households in Main Years in Guangxi (Unit: 10,000 units)

year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Color TV	90.04	91.98	92.91	93.66	93.90	94.91	95.19	96.42	97.65
washing machine	33.25	34.37	34.46	34.59	35.46	36.80	38.41	39.20	41.81
air conditioner	1.17	2.04	2.64	3.04	5.13	6.91	7.95	9.02	11.98
The refrigerator	12.94	13.95	14.46	15.42	16.33	17.67	19.61	20.87	21.87

Table 6 shows the number of urban and rural households in the main prime years of Guangxi.

Table 6: Number of urban and rural households in guangxi district in main years (Unit: 10,000 households)

year	2010	2011	2012	2013	2014	2015	2016	2017	2018
The total number of households	1140	1178	1197	1235	1285	1329	1374	1416	1487
Number of urban households	226.05	255.6	260.26	321.85	311.90	342.90	378.79	402.32	464.22
Number of rural households	913.95	922.40	936.74	913.15	973.10	986.10	995.21	1013.68	1022.78

According to Tables 4-6, the ownership of electronic products in Guangxi in major years is estimated, as shown in Table 7.

Table 7 The quantity of all kinds of electronic products in Guangxi in main years (Unit: 10,000 households)

year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Color TV	1589.97	1687.38	1798.18	1843.41	1938.74	2063.65	2092.04	2145.37	2150.26
washing machine	529.37	569.97	564.04	553.60	556.92	568.29	598.76	621.88	656.23
air conditioner	456.55	472.68	508.62	551.06	578.39	600.74	622.60	676.54	708.63
The refrigerator	508.09	533.39	551.16	606.28	610.56	649.90	706.14	738.26	762.35
year	221.16	235.20	255.36	275.18	295.85	348.96	377.65	403.02	418.36

3.1.2. Estimation of the generation of electronic waste in Guangxi from 2020 to 2025

In this paper, the "Stanford" estimation model established by Stanford Resources Co., Ltd. is used to estimate the used computers. This model is established on the basis of the investigation of the computer industry in the United States. Considering the gap between the development level of China's IT industry and that of the United States, and the current guiding ideology of advocating to extend the life of electronic products as far as possible to reduce the amount of waste, In this paper, the life period of the computer from 2010 to 2020 is modified into four grades : 6 years before 2010, 5 years from 2010 to 2012, 4 years from 2013 to 2016, and 3 years after 2017.Let the computer weigh 10kg.The annual waste computer production volume is estimated by the following formula: $Q=\sum_{i=3}^{6} S_i * p_i$, Where Q is the quantity of waste products produced in a certain year, $S_i(i=6,5,4,3)$ is the sales volume of computers calculated from the year i before, p_i is the percentage of computers sold in a previous year i discarded, let $p_6=10\%$, $p_5=35\%$, $p_4=40\%$, $p_3=15\%$.

The service life of household appliances is longer than that of computers. According to the estimate of experts from the China Institute of Household Electrical Appliances, the service life of televisions is about 8 years and the average weight is 10kg.Refrigerator, washing machine service life of about 10 years, the average weight: 45kg, 15kg;Air conditioning has a longer service life, about 11 years, with an average weight of 60kg.This paper uses the "market supply" estimation method, that is, the quantity of new products and product life to estimate the waste home appliances.

According to the above method and combined with the data in Tables 3-7, the main e-waste production volume in Guangxi is estimated as shown in Table 8-9 shows the predicted amount of electronic waste production in each city of Guangxi in 2020-2025.

Table 8: Total amount of e-waste generated in Guangxi in 2020-2025
(Unit: 10,000 tons)

2020	2021	2022	2023	2024	2025
3.85	4.57	5.28	6.05	6.86	7.90

Table 9: E-waste production amount of each city in Guangxi in 2020-2025
(Unit: ton)

	2020	2021	2022	2023	2024	2025
Nanning	6139	7214	8490	9800	11060	12578
Liuzhou	3920	4623	5320	6100	6996	8032
Guilin	4402	5204	6020	6956	7900	9020
Wuzhou	2297	2660	3010	3515	4050	4708
Beihai	1400	1580	1780	2024	2325	2869
Fangchenggang	804	990	1156	1302	1486	1648
Qinzhou	2353	2803	3202	3625	4130	4822
Guigang	2945	3582	4100	4696	5226	6035
Yulin	4060	4814	5530	6203	6956	8320
Baise	2610	3120	3652	4230	4862	5348
Hezhou	1602	1930	2212	2510	2865	3283
Hechi	2528	3078	3568	4083	4590	5180
Laibin	1790	2124	2401	2782	3156	3668
Chogzuo	1695	1996	2365	2680	3050	3475
Total	38545	45718	52806	60506	68652	78986

3.2. Recycling quantity of each node city is determined

According to the recycle status of Guangxi and based on consulting experts, this paper set the recycling rate of electronic waste at nodes of Guangxi as 50%.The production amount of major e-waste in the cities of Guangxi in 2020-2025 in Table 9 is estimated, so these values are fuzzy.

For example, the production amount of e-waste in Nanning in 2025 is 12,578 tons, which can be represented by the fuzzy amount (A, 12578, B).Now the key is how to determine A and B, which is the problem of determining fuzzy membership grade.

The decision maker's experience and environment determine the selection of fuzzy membership degree, which is closely related to optimum relation of fuzzy programming. In order to obtain better membership value of fuzzy parameters, fuzzy statistics method is used to calculate membership degree.

This paper analyzes the data in 2025 and assumes that the fuzzy membership mapping is within the range of 10% of the number of fuzzy centers. Thus, the fuzzy recycling amount of electronic waste in each city of Guangxi in 2025 is obtained, as shown in Table 10.

Table 10: Fuzzy recycling quantity of electronic waste in each city of Guangxi in 2015 (Unit: ton)

City	Fuzzy recycling quantity	City	Fuzzy recycling quantity
Nanning	(5660,6289,6918)	Guigang	(2716,3018,3220)
Liuzhou	(3615,4016,4418)	Yulin	(3744,4160,4576)
Guilin	(4059,4510,4961)	Baise	(2406,2674,2941)
Wuzhou	(2119,2354,2590)	Hezhou	(1478,1641,1805)
Beihai	(1291,1435,1578)	Hechi	(2331,2590,2849)
Fangchenggang	(742,824,906)	Laibin	(1651,1834,2018)
Qinzhou	(2170,2411,2652)	Chongzuo	(1564,1738,1911)

4. LINGO software programming solution

4.1. Calculation of OD volume between nodes in Guangxi cities

Set the freight as 1 unit and the recovery rate as 50%. Combined with Table 2 and Table 9, OD volume in each region can be calculated. The OD quantity from Nanning to Nanning is 12578*1/2=6289.OD quantity from Nanning to Liuzhou is 12578*262*1/2=1647718.The OD quantity from Liuzhou to Nanning is 8032*262*1/2=1052192.The rest can be similarly calculated as shown in Table 11.

Table 11: OD volume between nodes in each city
(Unit: ton)

City	Nanning	Liuzhou	Guilin	Hezhou	Wuzhou	Laibin	Hechi	Guigang	Yulin	Baise	Chongzuo	Qinzhou	Beihai	Fang-chenggang
Nanning	6,289	1,647,718	3,188,523	3,553,285	2,534,467	1,138,309	1,874,122	1,144,598	1,698,030	1,672,874	999,951	735,813	1,352,135	1,119,442
Liuzhou	1,052,192	4,016	983,920	1,216,848	1,871,456	325,296	783,120	763,040	1,132,512	2,072256	1,690,736	1,522,064	1,642,544	1,767,040
Guilin	2,286,570	1,104,950	4,510	983,180	1,718,310	1,470,260	1,546,930	1,966360	2,376,770	2,994,640	3,003,660	2,796,200	2,949540	3,071,310
Hezhou	927,448	497,375	357,847	1,642	275,772	630,336	817,467	638,544	631,978	1,344,389	1,188,446	1,007,881	1,063,692	1,108,013
Wuzhou	948,662	1,096,964	896,874	395,472	2,354	906,290	1,304,116	520,234	510,818	1,574,826	1,322,948	1,049,884	1,129,920	1,193,478
Laibin	331,954	148,554	597,884	704,256	706,090	1,834	506,184	199,906	368,634	819,798	623,560	546,532	601,552	658,406
Hechi	771,820	505,050	888,370	1,289820	1,434,860	714,840	2,590	862,470	1,098,160	857,290	1,183,630	1,074,850	1,328,670	1,232,840
Guigang	549,185	573,325	1,315,630	1,173,808	666,868	328,908	1,004,828	3,018	276,100	1,351,840	1,028,968	678,938	781,532	863,005
Yulin	1,123,200	1,173,120	2,192,320	1,601,600	902,720	836,160	1,763,840	382,720	4,160	2,229,760	1,784,640	1,381,120	965,120	1,634,880
Baise	711,284	1,379,784	1,775536	2,190,006	1,788,906	1,195,278	885,094	1,197,952	1,433,264	2,574	1,029,490	1,024,142	1,286,194	1,187,256
Chong	276	731	1,157	1,257	976	590	794	592	745	668	1,738	408	582	444

zuo	,263	,488	,175	,950	,475	,750	,038	,488	,388	,938		,312	,062	,800
Qinzhou	282,087	913,769	1,494,820	1,480,354	1,075,306	718,478	1,000,565	542,475	800,452	923,413	566,585	2,411	241,100	147,071
Beihai	308,418	586,711	938,163	929,556	688,560	470,516	735,898	371,536	332,804	689,995	480,558	143,450	1,434	230,954
Fang chenggang	146,672	362,560	561,144	556,200	417,768	295,816	392,244	235,664	323,832	365,856	210,994	50,254	132,564	824

4.2. LINGO software programming solution

Based on Table 1, Nanning is assumed to be the No. 1 node city, Liuzhou is the No. 2 node city, and so on, Fangchenggang is the No. 14 node city. Then, based on the data in Table 2 and Table 11, Lingo software is used to program the solution.

Some results after computer compilation and calculation are as follows:

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Global optimal solution found at iteration:  6227020800
Objective value:              102160000
Z(1)        1.000000       20195000
Z(2)        1.000000       40890000
Z(8)        1.000000       41075000
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5. Result analysis

The global optimal result of the first stage is to establish transit warehouses in Nanning, Liuzhou and Guigang. Therefore, it is analyzed that the node of the treatment center and the landfill site in the second stage can be located in Nanning, Liuzhou, Guigang or the node city Laibin between the three. Considering that Nanning is a provincial capital city, it is not suitable to be an e-waste disposal and landfill center. Therefore, Liuzhou, Guigang and Laibin are considered as disposal centers and landfill sites.It is noted that Qinzhou has a unique geographical location, which can be used as a secondary storage and transfer center between Fangcheng Port and Beihai City, and the waste can be transported to Nanning or your port for storage.Considering the special environment of Nanning, the e-waste collected in Qinzhou is transported to Guigang for storage.

Assuming that the guest is the treatment and landfill node, the transportation route and facility scale of each node can be obtained. That is, Guilin, Hezhou, Hechi, Liuzhou electronic waste transported to Liuzhou storage, storage after a certain scale shipped to the guest processing, landfill; Baise, Chongzuo, Nanning electronic waste transported to Nanning storage, storage of a certain scale after shipped to the guest processing, landfill; The e-waste from Fangchenggang and Beihai is first transported to Qinzhou for collection, and then the e-waste from Qinzhou, Yulin, Wuzhou and Guigang is transported to Guigang for storage. After storage of a certain scale, the e-waste is transported to Laibin for disposal and landfill. The scale of each storage point and the processing scale of the processing center (provided that the precipitation ratio of materials is 0.2) can be calculated by multiplying the sum of adjacent nodes by the coefficient 1.5 (considering the two factors of construction cost and peak recycling volume). The landfill scale can be calculated by multiplying the processing scale by the coefficient 0.8.The e-waste reverse logistics network of Guangxi is shown in Fig 1.

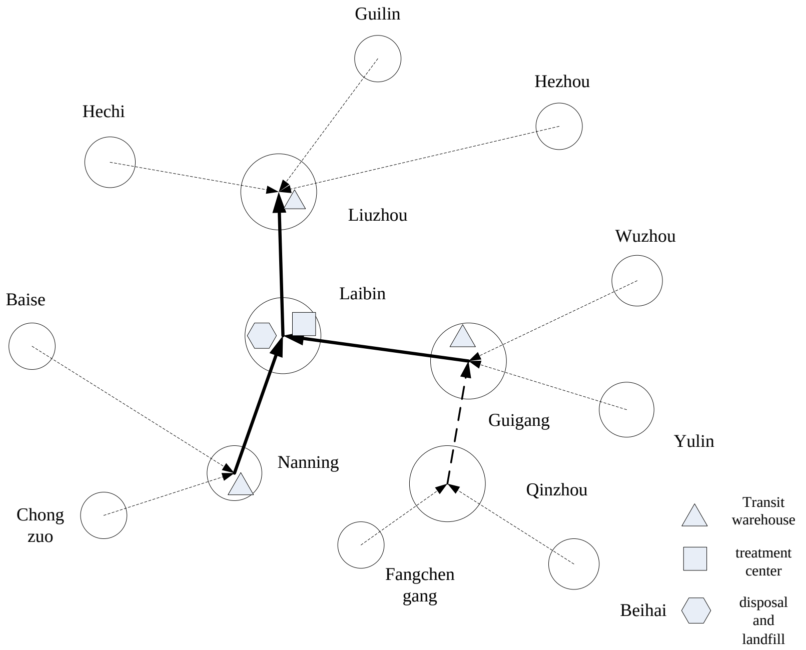

Fig 1: Electronic waste reverse logistics network diagram of Guangxi District with Laibin as the disposal and landfill node

Similarly, if Liuzhou or Guigang are chosen as the treatment center and landfill site, the transportation route and facility scale of each node can also be obtained accordingly. The transportation route changes as follows: when Liuzhou is the node for disposal and landfill, the guest electronic waste will be transported to Liuzhou for storage, disposal and landfill. When your port is the node for disposal and landfill, the guest e-waste will be transported to your port for storage, disposal and landfill. The sizes of the storage centers, processing centers and landfills are shown in Table 12.

Table 12: Select Laibin, Liuzhou or Guigang as the node size of each facility of the processing center

(Unit: ton/month)

Logistics node	Liuzhou (storage)	Nanning (Storage)	Qinzhou (secondary storage)	Guigang (storage)	Laibin (disposal/landfill)
Size	1595	1338	583	1775	7290/5832
Logistics node		Nanning (Storage)	Qinzhou (secondary storage)	Guigang (storage)	Liuzhou (storage)
Size		1338	583	3550	7290/5832
Logistics node	Liuzhou (storage)	Nanning (Storage)	Qinzhou (secondary storage)		Guigang (storage)
Size	1595	1338	583		7290/5832

6. Simulation study of Guangxi electronic waste reverse logistics system

Above to set up a network stage model of electronic waste reverse logistics system to GuangXi District construction of e-waste recycling network as an example, the application of Lingo9.0 software programming has realized the numerical example, and gives the three possible network choice, namely to liuzhou, guests or your port as the processing center and landfill site to build a network, how to choose, Simulation software can be used for simulation and discussion. In this paper, 3D simulation software Flexsim was selected for simulation.

6.1. Establishment of simulation model of Guangxi e-waste reverse logistics system

According to Figure 1, this paper holds that each city node is a temporary entity, equivalent to an e-waste resource generator, while Liuzhou, Guigang and Nanning are also equivalent to temporary storage areas, and Laibin is both a processing center (processor) and a landfill (absorption container).Fig. 1 is converted into the simulation flow chart of Guangxi electronic waste reverse logistics system, as shown in Fig. 2.

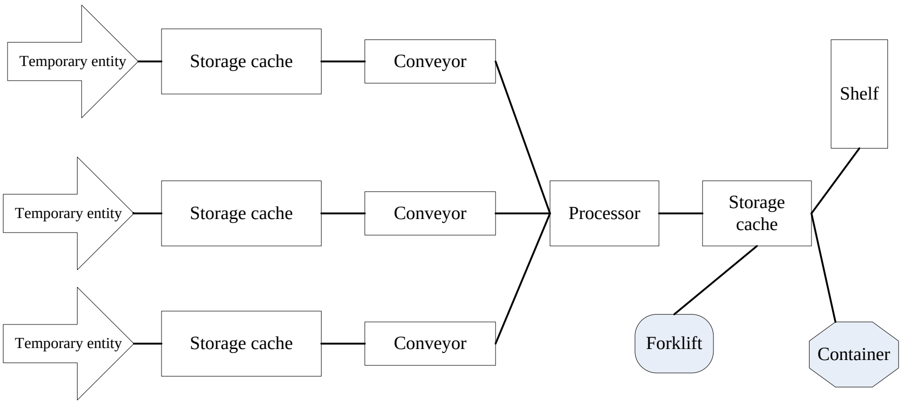

Fig. 2: Simulation flow chart of Guangxi electronic waste reverse logistics system

The simulation model was constructed from the simulation flow chart 2.Drag out the required entity objects from the Flexsim object library, put them into the view window, and connect them according to the corresponding logical relationship to form the simulation model view, as shown in Figure 3.

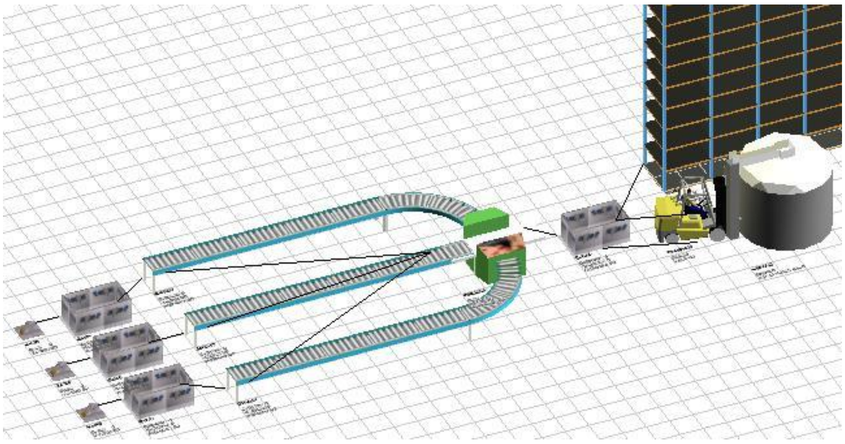

Fig. 3: 3D view of simulation model of Guangxi electronic waste reverse logistics system

6.2. Simulation model operation and result analysis

Parameter the entities in Figure 3 by referring to the data in Table 12 and the properties of each entity. After setting the parameters of the simulation model, there is a Flexsim simulation model corresponding to the initial scheme. Click the Compile, Reset, and Run buttons in the lower left corner of the Simulation View window. To get more accurate statistics, let the simulation model run at least 50,000 seconds.

To observe the simulation results, observe the recording method of Recorder added in the view window, observe the exported standard statistical report method or observe the status, quantity and stay label of the "statistical" item in the attributes of each entity by using the chart method. This paper will analyze the simulation results of the model through the exported statistical report. After selecting the entity you want to Report, select the menu option "Statistics - Standard Report" to see the Standard Report Setup window. Click the "Create Report" button to generate a Standard Report.

According to the statistical data from the standard report exported by the simulation system (G5-G7 data), it can be seen that the Sourse1, Queue4, Conveyor7, Processor10, Queue15 team runs in good quality. And Sourse2, Queue5, conveyer OR8, Processor10, Queue15 and Sourse3, Queue6, conveyer OR9, Processor10, Queue15 run in bad quality, This indicates that there is a time difference in the quality of the network system model between the disposal center and the landfill site, so it can be judged that the task balance does not meet the design requirements, that is, the whole e-waste reverse logistics system is not optimal.

6.3. Analysis of simulation results for adjusting network allocation scheme

In order to ensure the comparability between the adjusted system and the original system, the original entity process and parameter Settings should be kept unchanged as far as possible. What needs to be changed is that the transportation time of electronic waste from Gui gang or Liuzhou nodes to the treatment center is quite short. Similarly, let the simulation model run at least 50,000 seconds, and when the simulation is finished, export the standard report.

Similar analysis report statistical data from the simulation system of export standard (G5-G7 data) can be seen in your port for processing center and network system simulation model of landfill, three groups running quality is good, in running quality is superior to the guests and liuzhou as the processing center and landfill operation quality of network system model. In other words, the optimization of the whole e-waste reverse logistics system has been improved.

6.4. The result

By constructing the stage model of Guangxi electronic waste reverse logistics network, and using Flexsim simulation software to simulate and analyze its possible network structure, the optimization of Guangxi electronic waste reverse logistics system network is finally completed. Liuzhou, Nanning and Guigang are regarded as the first-level transit storage centers, Qinzhou as the second-level transit storage centers, and Guigang as the processing center and landfill site. Its reverse logistics network is shown in Figure 4.

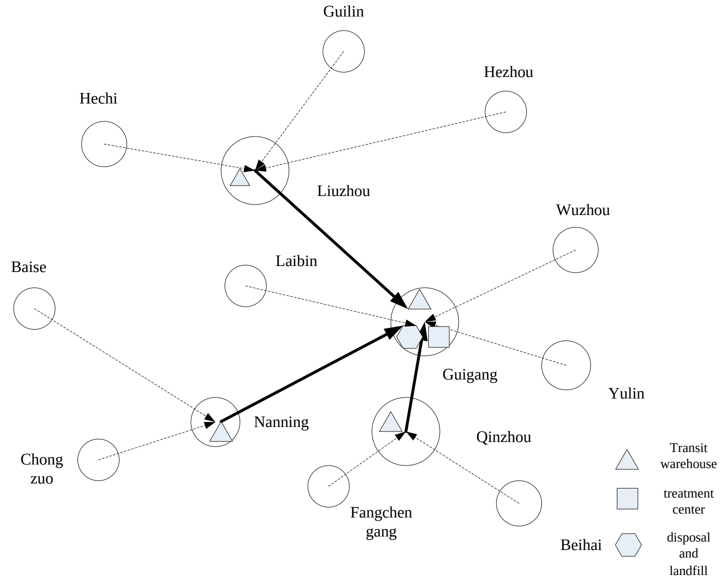

Fig. 4: Guangxi e-waste reverse logistics network with Guigang as the disposal and landfill node

The scale of each network node is shown in Table 13 (unit: ton/month).

Table 13: Size of each network node

Logistics node	Liuzhou (storage)	Nanning (storage)	Qinzhou (secondary storage)	Guigang (disposal/landfill)
Size	1595	1338	583	7290/5832

7. Conclusion

This paper mainly studies the simulation of Guangxi electronic waste reverse logistics system network, and establishes the simulation model of Guangxi electronic waste reverse logistics system by using Flexsim simulation software. Through the analysis and simulation results, a better selection of Guangxi e-waste reverse logistics system network is given, that is, Liuzhou, Nanning and Guigang are used as the first-level transit storage center, Qinzhou is used as the second-level transit storage center, and Guigang is used as the treatment center and landfill site.

With the increase of the amount of waste, the original system will not be able to meet the requirements, so it is necessary to consider whether to build new facilities or expand facilities, and these changes of facilities will lead to the change of transportation routes, which requires us to study the scalability of the system design of the electronic waste network.

Logistics system simulation has the advantages of intuitionism and practicality, but it is also limited by simulation scale and data variables. The following research work should include modifying the physical parameters of the system, analyzing the simulation results and finding the logistics "bottleneck", so as to optimize the whole reverse logistics network.

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