CHAPTER 4 -ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

For the purpose of analysing the supply chain of Unilever Sri Lanka Ltd., products were divided in to three major categories of Homecare, Personal care and foods. These were again divided in to 8 sub categories. This was done inline with the Unilever international categorization, so that it is helpful for benchmarking with other factories. Summary of the categorized products are included in table 3.

4.2 Identifying product categories for the evaluation of Environment Performance

Grandpass and Lindel are Unilever own manufacturing units and MAS-Dambulla, Katana -CPC, etc. are third party factories. The environment performance is measured to a greater extent and systems are in place to ensure proper environment management at the Unilever own units as compared to the 3P units. Further, access to information is easier at own locations (GP and Lindel). On the other hand, 95% of the locally manufactured products are coming out from these factories. Hence the study was limited to products getting manufactured at Lindel and Grandpass Factories.

Accordingly the following 9 secondary sub categories were initially considered for the purpose of this research;

A.) Laundry Soap (sunlight)

B.) Powders (Surf Excel , Rin, Sunlight Detergent powder)

C.) Toothpaste (Signal)

D.) Skin Cleansing Soaps (Lifebuoy, Lux, Pears)

E.) Creams and Lotions (Ponds, Pears)

F.) Shampoo and Conditioner (Sunsilk, Lifebuoy, Clear , Pears)

G.) Spreads (Astra, Flora , Industrial margarines)

H.) Cologne (Pears)

I.) House Hold Care Bars (Vim)

Category	Sub category - 1	Sub category - 2	SKU	Tonnage 2008	Location Manufacturing	Location Packing
HOME CARE	Laundry	Soap	Sunlight	27,883	GP	Lindel
			Wonderlight		GP	Lindel
		Powder	Rin	3,726	Lindel	Lindel
			Surf Excel	7,284	Lindel	Lindel
			SLDP	2,540	Lindel	Lindel
			Sunlight	2,207	GP	Lindel
			Wonderpower	-	GP	Lindel
	HHC (House hold care)	Vim	Powder	652	Lindel	Lindel
			Wonderclean	-	Lindel	Lindel
			Bar	6,254	RMC	RMC
			Liquid	477	GP	GP
PERSONAL CARE	Oral care	TP	Signal	2,811	GP	GP
	Skin care	Toilet Soaps	LUX	2,834	GP	GP
			Lifebuoy	12,770	GP	GP
			Pears	2,130	GP	GP
		Face care (powder)	Pears	110	Lindel	Lindel
			Ponds	127	Lindel	Lindel
		Body care(Cream / lotion)	Pears Cream	323	GP	GP
			Pears Oil	24	GP	GP
			Ponds	32	GP	GP
		Cologne	Pears	136	Lindel	Lindel
	Hair care	Shampoo	Sunsilk	1,131	GP	GP
			Clear	115	GP	GP
			Pears	19	GP	GP
			Lifebouy	430	GP	GP
		Conditioner	Sunsilk	31	GP	GP
FOODS/ BEVERAGES	TBB	Tea	Ceylonta	2,574	3P	3P
	SCC	Spreads	Astra	4,198	GP	GP
			Flora	187	GP	GP
			Marmite	280	Katana	Katana
		Culnary & Cooking (Knorr)	Cubes	412	Katana	Katana
			Chinese	9	Mas-Dambulla	Mas-Dambulla
			Soups	7	Mas-Dambulla	Mas-Dambulla
Total Volume in Tons				**81,713**		

Table 4.1 Product Categories of Unilever SL and 2008 tonnage

The cumulative tonnage of these categories amounts to 95 % of the total production in 2008. This categorization was presented to the evaluation panel during the progress presentation and the feedback given was to limit the study to only few categories. Idea was to concentrate more few categories to increase the quality rather than extensive data

collection. As such, categories with some similarities were clubbed together and the following categories were selected for the purpose of this study.

A.) Soaps (laundry soaps and toilet soaps)

B.) Powders (Soap powders and detergent powders)

C.) Toothpaste

D.) Liquids (Shampoo, conditioner)

E.) Spreads (Margarine)

4.3 Identifying Key Environment Principles

Key environment Principles groups related to supply chain of USL were identified based on the company practices, Unilever regional guidelines and internationally accepted sustainable performance reporting frameworks such as GRI (G3) and ISO 14031.

By analysing the principles identified by Tsoulfaf & Pappis, G3 environment aspects and ISO guidelines, five groups of environmental principles which are related to Unilever supply chain were derived. Summary of the comparison is shown in the table below;

	Groups of principles defined by Tsoulfaf & pappis	G3 Guide lines Aspects	ISO 14031 indicator Category	Groups of Principles Developed For the study on Unilever SL supply chain
1	Product, Process Design	Materials	OPI	Manufacturing design
		Energy	OPI	
		Water	OPI	
		Emissions, effluents and Waste	OPI	
2	Packaging	Materials	OPI	Packaging
		Energy	OPI	
		Water	OPI	
3	Transportation and collection	Transport	OPI	Logistics
4	Recycling and disposal	Emissions, effluents and Waste	OPI	Waste Handling
		Energy	OPI	
		Water	OPI	
4	Greening the internal and external business environment	Biodiversity	ECI	Overall Management
		Product and Services	MPI	
5	Other management issues	Compliance	MPI	
		Overall	MPI	
		Product and Services	MPI	

OPI Operational Performance Indicator
MPI Management Performance Indicator
ECI Environmental Condition Indicator

Table 4.2 Environmental Principle Groups Applicable to USL

Considering the facts such as convenience of analysis, availability of data, current literature, etc., the study was limited to four groups of environmental principles.

Group A - Manufacturing Design

Group B - Packaging

Group C - Logistics

Group D - Waste Handling

The above groups cover all the major aspects of the supply chain of Unilever Sri Lanka. The Environmental Performance of the product categories identified in section 4.2 is analyzed with respect to each of the groups to measure the environment performance of the supply chain using the methodology explained in chapter 3.

4.3.1 Manufacturing Design (Group A)

The Manufacturing design process includes products as process design development, which are closely interrelated and greatly influence the environment. Design has to take in to account the effect of design detail on energy/material requirements for manufacturing, use and secondary use, etc. The principles related to this group such as minimizing the use of material, energy, water, etc and increasing the recyclability, etc demonstrates the products positive impact on the environment.

4.3.2. Packaging (Group B)

Packaging affects the environment in many aspects and regulations concerning packaging constitute an essential part of governmental policies for environment protection. Most principles applicable to manufacturing design are applicable to packaging too. In addition to those environmental principles such as limit packaging to necessary size and increase the recyclability, etc can be considered for packaging.

4.3.3 Logistics (Group C)

In logistics the major aspect considered is transport and Material handling in the warehouse. The environment directly gets impacted from these activities and it is important to measure the environment performance of all the products on the

environmental principles related to logistics such as minimizing the distances and using efficient modes of transports, etc.

4.3.4 Waste Handling (Group D)

After the useful life, a used product may be either disposed or recycled. If it is disposed either it can be incinerated or it can be used for land fill or in some cases can be used as an energy source. On the other hand if recycled, that will save new row materials and sometimes the energy. For example, recycling of glass saves lot of energy and material. Hence it is very important to assess the environmental performance in relation to the principles of waste handling.

4.4 Developing Environmental Performance (EP) Indicators

Under each group identified above, Environmental Performance (EP) Indicators were developed. GRI initiatives, ISO 14031 guidelines, general company practices and common literature available in developing the most suitable EP indicators to evaluating the environment performance Unilever Sri Lanka (USL) supply chain.

	Environmental Principle Group	Aspect	Description	Environmental Performance (EP) Indicator	Index
Group A	Manufacturing Design	Materials	Weight or Volume of Row Material (RM)	g/Unit of Product (Average across SKUs)	EP1
				Tons/year (2009 Volumes)-Latest Forecast	EP2
			Use of recycled Material	Recycled matter %	EP3
		Waste	Waste water discharged	m^3 / Ton of product	EP4
			Green House Gas emissions (CO2)	Tons/year	EP5
				Tons/Ton of product	EP6
			Non Hazardous Waste generated	Kg/Ton of product	EP7
				Tons/Year	EP8
		Energy Consumption	Total Energy Consumption	GJ/Year (2009 latest forecast)	EP9
				GJ/ Ton of product (2009)	EP10
			Energy Conserved	GJ / year against 2008	EP11
		Water	Total water Usage	m^3 / Ton of product	EP12
Group B	Packaging	Materials	Paper/Plastic Usage	tons/ year (2009 data)	EP13
		Recyclability	Percentage of packaging content that can be recycled (%)	%	EP14
		Waste	Waste material	kg/ year	EP15
Group C	Logistics	Transport	Fuel Consumption for distribution	Litres/km	EP16
				Litres/Million Units	EP17
		Forklift moveme	Weekly Movements	Pallets/week	EP18
Group D	Waste Handling	Emissions	Reduction achieved in GHG	CO2/year (against 2010)	EP19
		Energy	Diesel consumption for waste handling	L/year	EP20
		Water	Water reuse	% Water re-use	EP21
		Waste	Landfill	Tons/year	EP22
			Incineration	Tons/year	EP23

Table 4.3 EP indicators developed to Evaluate the supply chain of USL

Initially 23 EP indicators shown in table 4-3 were selected for the study and data was collected. In subsequent revisions to the study, EP5, EP8 and EP9 were removed from the analysis to make the final result more accurate. Brief description of EP indicators developed under several aspects such as materials, energy, waste, etc. for each of the environment principle groups are as follows;

4.4.1 EP indicators related to Materials Aspect

The weight of the raw materials (RM) for EP 2 was recorded based on the volume forecast for 2009 from the annual demand plan of USL. This was considered as an important factor in measuring EP as use of RM depletes the resources.

Same demand plan was used to identify the million units for each of the Stock Keeping Units (SKU) product categories. EP 1 was calculated as the average weight of a unit using the sum-product of all the SKUs s of a particular category. This analyze the "per unit" RM consumption

Under Group B packaging, EP 13 was derived using the packaging material forecast for 2009. The weekly packaging material consumption was converted to the annual figure.

4.4.2 EP indicators related to Recyclability Aspect

Assessing EP 3 was a difficult aspect to measure because of the lack of the consistency of the recycling activity. This was quite low across all the product categories. The amount can be recycled depends on the hygienic factors, especially when it comes to food items such as margarine. Figures were arrived by analyzing the past records and interviewing the experienced plant managers of USL. EP 14 under packaging also was obtained in a similar manner.

4.4.3 EP indicators related to Waste Aspect

Waste water discharged (EP4) was measured through the 'V' notches placed in drains to the effluent treatment plant from respective manufacturing facilities. Non hazardous waste generated (EP8) was collected from the Unilever data sheets which are quarterly

reported to the regional Safety, Health, Environment (SHE) teams. Since it is important to measure the absolute value of waste as well as waste generated per ton of finished products, EP 7 was developed.

EP 7 and EP 8 were calculated based on the green house gas (GHG) emissions reported at USL. The main source of GHG generation is energy used in the plant. Steam energy and electricity energy were converted to CO2 emissions using standard formulas to calculate this. EP 19 is the reduction in GHG emissions in group D. This was derived using the % reduction of GHG emissions of 2009 against the 2008 recorded figures.

EP 15 was derived as percentage of the total packaging material used after going through past records and getting the feed back from experienced plant managers. Water re-use is captured in EP 21 as the % of water re used, which were actually recycled at the effluent treatment plant. EP 22 and EP 23 , landfill and incineration records again were taken from the EP data recorded at USL and reported to the regional SHE team. These were major EP indicators under 'Waste Handling', group D. Relevant types of waste for each product group was identified by experience.

4.4.4 EP indicators related to energy /water aspects

The EP's falls under this category are very important ones as far as the environment impact is concerned. At USL, a proper monitoring mechanism is available for measuring the steam, electricity and water consumption by each of the product categories. These data are properly recorded and reported monthly. EP 9, EP 10 and EP 12 were derived from these figures. It was important to measure the absolute usage of energy as well as the per ton usage in comparing the different product categories. Energy conserved (EP 11) was based on the reduction in 2009 against 2008 equivalent period. Diesel consumption per year for incineration was used as the measure for EP 20.

4.4.5 EP indicators related to logistics

These records were obtained from the logistics department and certain calculations were performed to obtain the average fuel consumption, etc. EP 16, EP 17 and EP 18 were developed on actual numbers available at USL for each of the product categories of USL. The lorry movements and the tonnages were related to see the true impact on the environment.

4.5 Data collection

Data were collected using the methods described in the previous chapter. Data Collected for each of the EP indicators are summarized in the below table;

	ntal Principle Group	Aspect	EP indicator	Index	Category	Soaps	Powders	Toothpaste	Shampoo	Spreads
	Manufacturing Design	Materials	g/Unit of Product (Average across SKUs)	EP1	n	104	52	52	8	126
			Tons/year (2009 Volumes)-Latest Forecas	EP2	n	53,917	19,447	3,560	2,141	4,836
			Recycled matter %	EP3	p	8%	5%	2%	5%	2%
		Waste	m^3 / Ton of product	EP4	n	0.69	0.34	0.46	1.5	2.0
			Tons/year	EP5	n	2,557	572	213	98	1,071
			Tons/Ton of product	EP6	n	0.05	0.03	0.05	0.05	0.22
			Kg/Ton of product	EP7	n	0.88	5.3	7.2	10.9	2.1
			Tons/Year	EP8	n	47	103	26	23	10
		Energy Consumptio	GJ/Year (2009 latest forecast)	EP9	n	95,560	12,242	3,723	1,649	46,185
			GJ/ Ton of product (2009)	EP10	n	1.77	0.63	1.05	0.77	9.55
			GJ / year against 2008	EP11	p	34,098	2,129	829	226	-
		Water	m^3 / Ton of product	EP12	n	0.85	0.42	0.52	2.4	2.48
p B	Packaging	Materials	tons/ year (2009 data)	EP13	n	4,819	5,222	3,782	1,363	2,476
		Recyclability	%	EP14	p	80%	30%	60%	30%	60%
		Waste	kg/ year	EP15	n	48	52	113	68	74
	Logistics	Transport	Litres/km	EP16	n	0.25	0.21	0.19	0.15	0.18
			Litres/Million Units	EP17	n	578	333	368	98	903
		Forklift mover	Pallets/week	EP18	n	2,262	1,449	416	317	460
	Waste Handling	Emissions	CO2/year (against 2010)	EP19	p	912	99	47	13	-
		Energy	L/year	EP20	n	1,119	268	889	1,003	542
		Recyclability	% Water re-use	EP21	p	82%	80%	90%	65%	83%
		Waste	Tons/year	EP22	n	66	142	100	55	68
			Tons/year	EP23	n	29.4	12.5	39.5	36.7	16.0

Table 4.4 EP indicator Summary

4.6 Analysis Using Saaty's AHP model.

As described in chapter 3, the software "expert choice" was used to analyze the EP using Saaty's AHP model. The basic elements of the model can be summarized as follows; The basic modeling of the problem can be shown as in figure 4.1

- **Goal** - Goal: Establish the EP of supply chain of Unilever SL for different product categories
- **Alternatives** – Soaps, Powders, Toothpaste, Shampoo and Spreads

  (These are the product categories, for which the EP will be analyzed and interpreted.)
- **Criteria** - Manufacturing Design, Packaging, Logistics and Waste handling
- **Sub Criteria** – The respective EP indicators identified earlier, listed in table 4.4

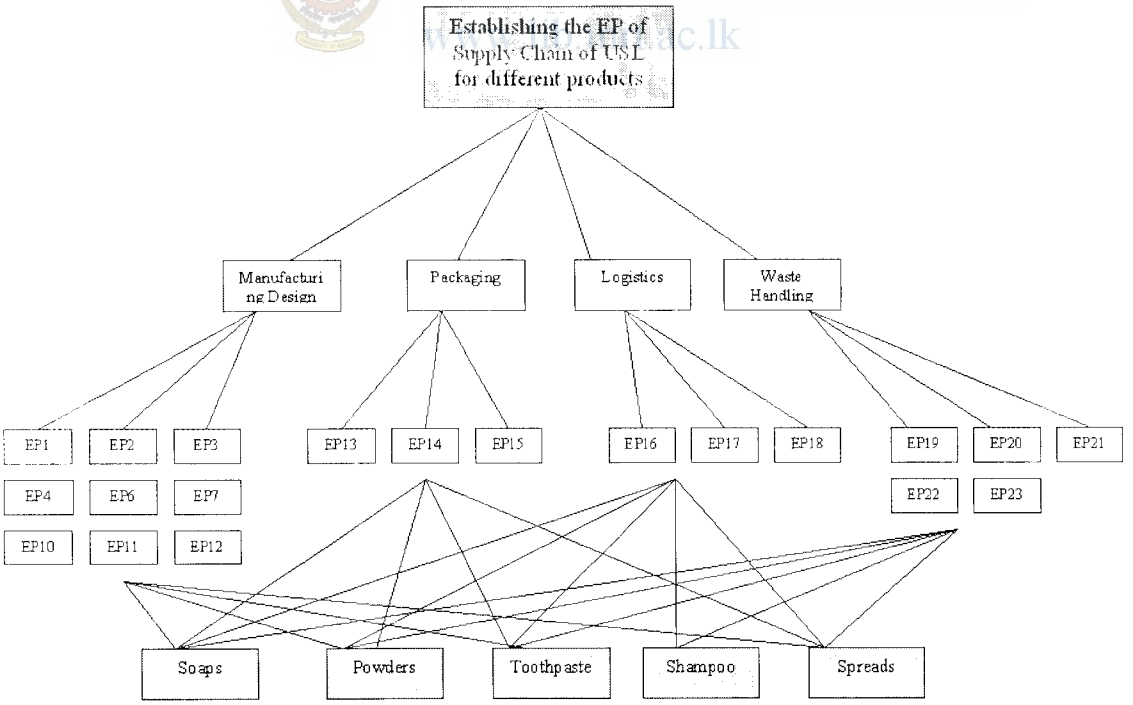

Figure 4.1 Modeling the problem using AHP

With these elements, the basic model will be prepared. A screen shot of the model is available in figure 4.2

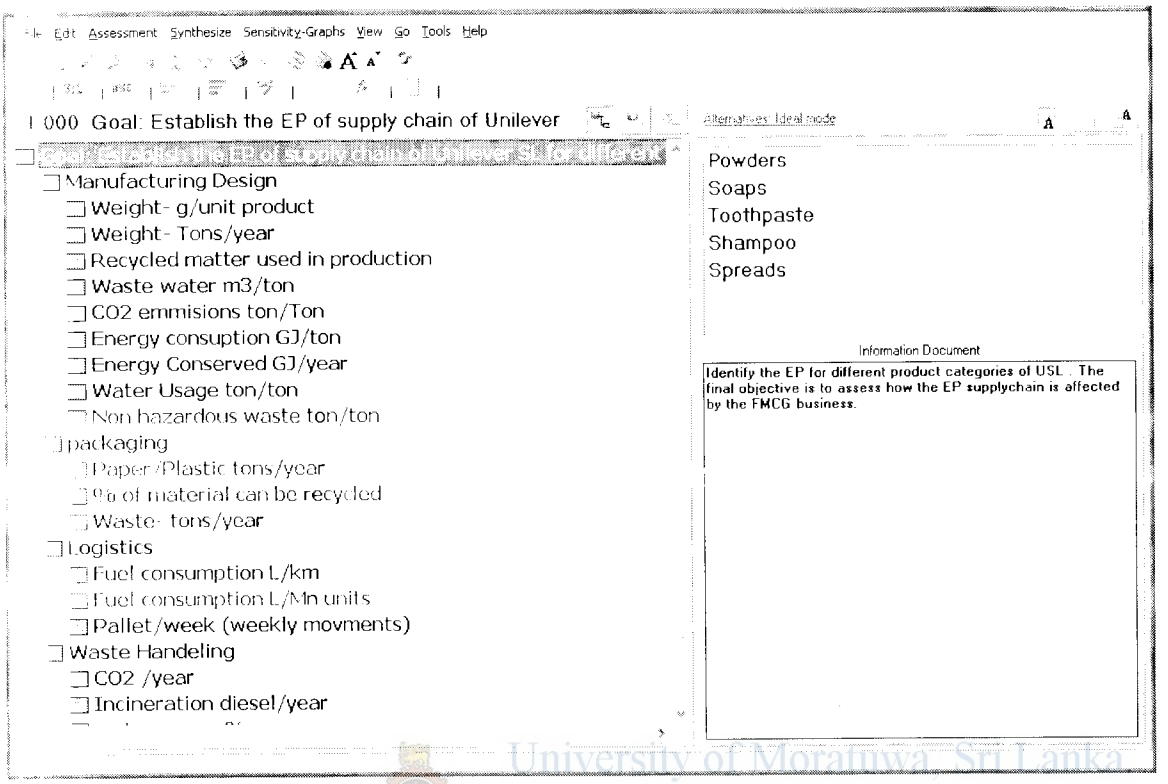

Figure 4.2 Modeling the problem using expert choice

next step would be to assign priorities to the criteria. Pair wise comparison is done using a scale of 1 to 9.

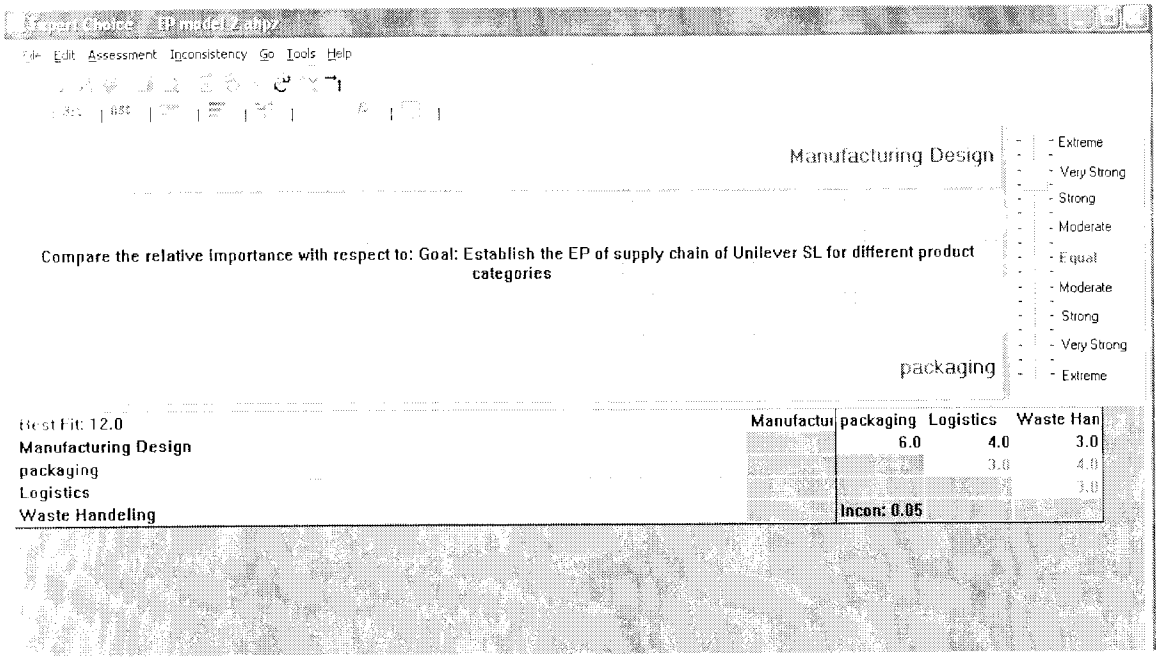

Figure 4.3 establishing priorities to criteria

Manufacturing design is more than strong when compared to packaging; hence 6 positive marks were given for that. Similarly, the pair wise comparison is done to establish the priorities among the environment principle groups. The established priorities are as shown in figure 4.4

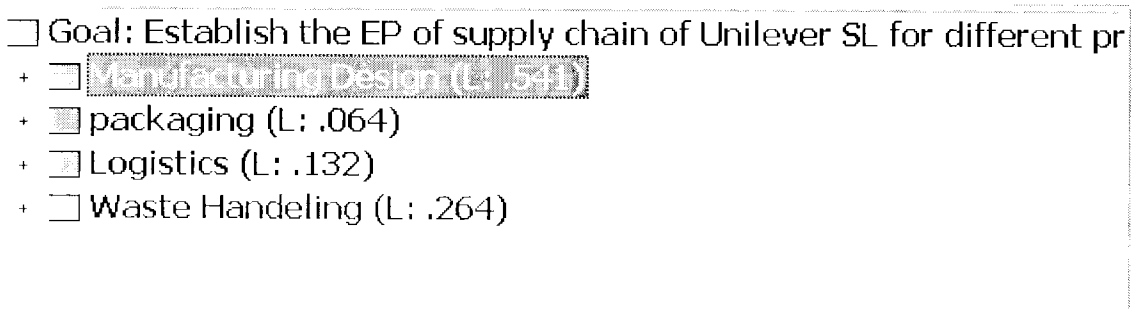

Figure 4.4 Established priorities for environment principle groups.

One fundamental assumption is that the priorities established above are valid for each of the alternatives. (Product categories) I.e. when you consider Soaps, powders, etc, the weights given to each of the criteria will remain constant. This is true because with respect to the final goal (to establish EP), which criteria is important is determined by the weights given to the criteria, and with respect to Unilever Sri Lanka, the importance or priority given to criteria's such as logistics, packaging will remain same across the product categories.

Next step is establishing the priorities of the sub criteria (EP indicators) within main criteria. A similar process as described above to be followed here as well. Figure 4.5 shows the model after assigning all the priorities to sub criteria.

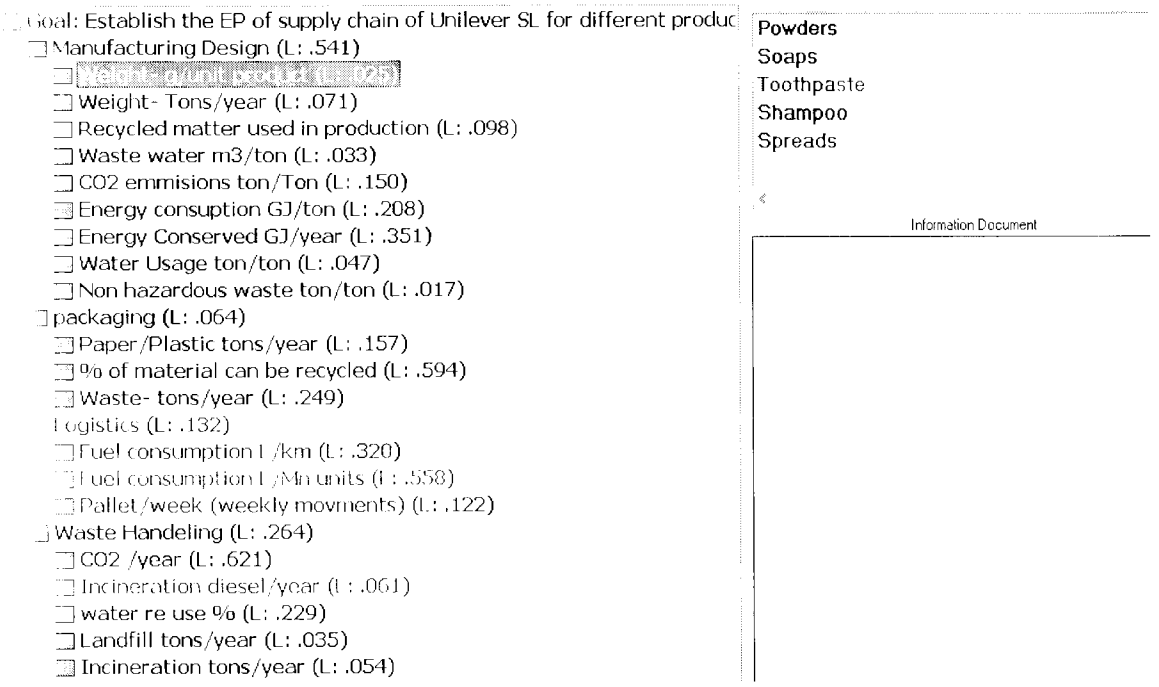

Figure 4.5 Priorities of sub criteria.

Now the important part is to compare the alternatives (product categories) against each of the sub criteria. The data collected for each of the EP indicator will be used here. Depending on the effect on environment, the values will be positively or negatively considered. I.E. higher the value of a negative indicator such as energy consumption will get lower value in the comparison. All the data needs to be carefully analyzed and the numbers should be assigned to each pair as per the scale shown earlier. A sample of assigning the weights is shown in figure 4.6.

It demonstrates the values assigned to each of the comparisons under the criteria, energy consumption. Soaps are assigned negative marks compared to toothpaste or shampoo, due to the higher energy consumption. How many marks assigned depends on the difference in actual data. However, this judgment may slightly vary from one researcher to another. The software gives an idea about the consistency of the judgment also as indicated by incon 0.03" in figure 4.5

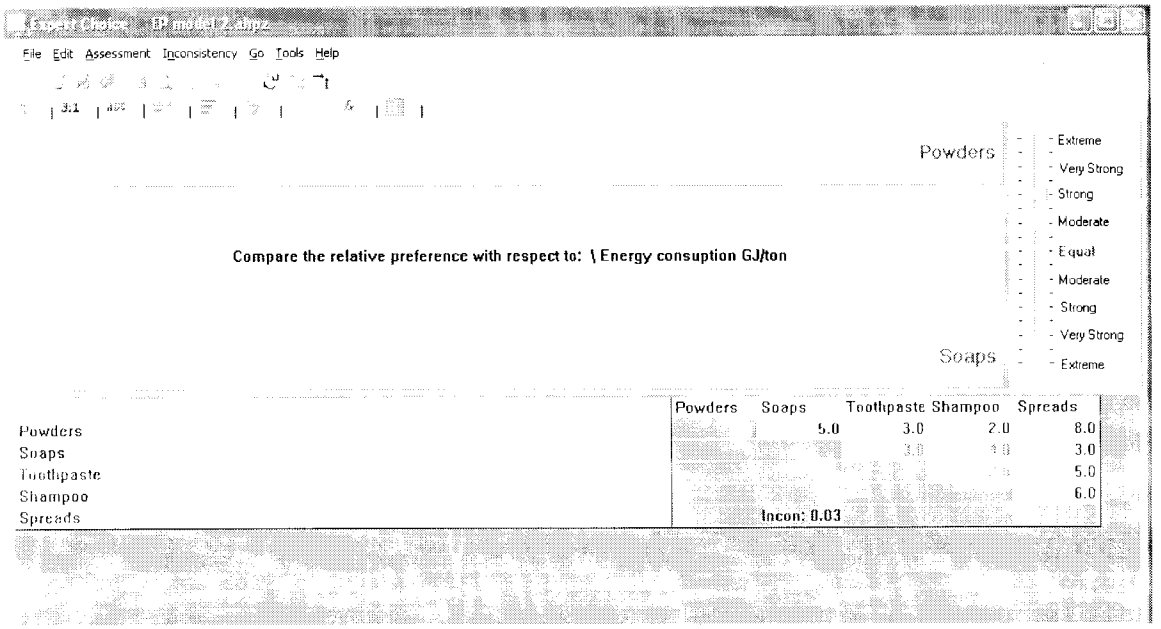

Figure 4.6 Pair wise comparison of product categories for the criteria energy consumption

This exercise is repeated for all the environmental performance indicators, to establish the EP of the product categories, across the supply chain of USL.

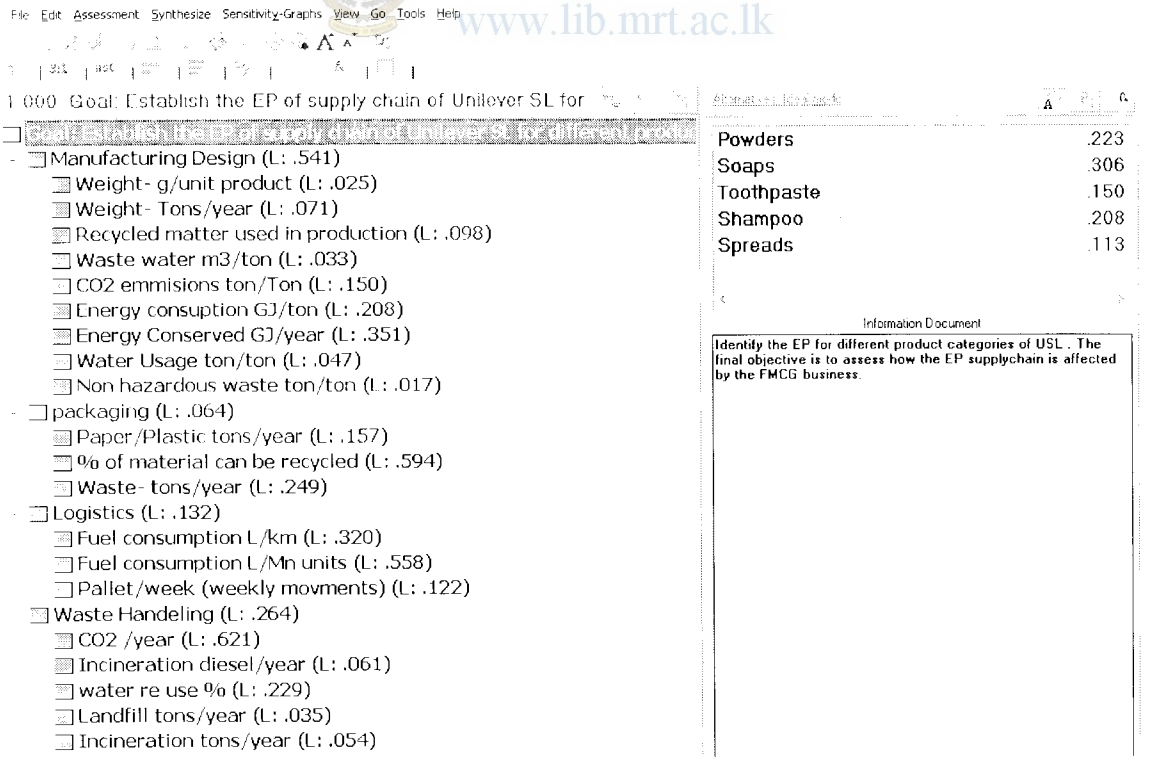

Figure 4.7 Final comparison of the AHP model

Once all the pair wise comparisons are done, the model automatically calculates the priorities for the alternatives, with respect to the Goal identified. Figure 4.7 shows the ultimate result of the study. The figure shows the final values obtained by the product categories and the priorities of each criteria and sub criteria.

The result shows that Soaps are having a better EP compared with other products and the overall performance of spreads is poor. The performance of the product in each criteria or sub-criteria can be studied to analyze how the numbers are arrived. This will give a very clear picture of EP across the supply chain of USL for different product categories.

4.7 Analysis using the model by Tsoulfaf and Pappis (2006)

4.7.1 Classification of EP indicators

Classification of the above indicators was done based on whether their values positively or negatively related with the environmental impact incurred. Notations 'p' and 'n' were used to indicate the 2 categories. Values were assigned for each product category based on their performance. Further analysis was conducted as per the methodology explained in chapter 3.

4.7.2 First Level of analysis

Each of the values of the 'p' EP indicators was normalized to their total and each of the 'n' indicators was normalized using the inverse values. The results are shown in the below tables;

Group A

		Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP3	Recycled matter %	0.36	0.23	0.09	0.23	0.09
EP11	Energy Conserved GJ/y	0.91	0.06	0.02	0.01	0.00

Table 4.5 Normalized Values for p indicators (Group A)

		Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP1	g/Unit of Product (Aver	0.053	0.106	0.106	0.691	0.044
EP2	Tons/year (2009 Volum	0.018	0.050	0.274	0.456	0.202
EP4	Effluents m^3 / Ton of pro	0.188	0.383	0.281	0.084	0.064
EP6	GHG tons/ton	0.215	0.346	0.170	0.223	0.046
EP7	Waste kg/ton of product	0.559	0.093	0.068	0.045	0.235
EP10	Energy GJ/ton	0.125	0.352	0.212	0.288	0.023
EP12	Water m3/ton	0.187	0.375	0.307	0.067	0.064

Table 4.6 Normalized Values for n indicators (Group A)

Group B

		Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP14	Packaging- % can be re	0.31	0.12	0.23	0.12	0.23

Table 4.7 Normalized Values for p indicators (Group B)

		Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP13	Paper/Plastic Usage ton	0.115	0.106	0.147	0.407	0.224
EP15	Waste KG/year	0.270	0.249	0.115	0.191	0.175

Table 4.8 Normalized Values for n indicators (Group B)

Group C

		Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP16	Litres/km	0.152	0.181	0.201	0.254	0.212
EP17	Litres/Million Units	0.092	0.160	0.145	0.544	0.059
EP18	Pallets/week	0.050	0.078	0.271	0.356	0.245

Table 4.9 Normalized Values for n indicators (Group C)

Group D

		Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP19	CO2/year reduction	0.85	0.09	0.04	0.01	0.00
EP21	Water Re use	0.20	0.20	0.22	0.16	0.21

Table 4.10 Normalized Values for p indicators (Group D)

		Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP20	Diesel consumption for	0.104	0.435	0.131	0.116	0.215
EP22	Landfill	0.233	0.108	0.154	0.281	0.225
EP23	Incineration	0.148	0.348	0.111	0.119	0.274

Table 4.11 Normalized Values for n indicators (Group D)

4.7.3 Second Level of analysis

The next step is to calculate h_{jk} among the indicators within the same group of indicators. Squared matrices are formed for each group of indicators (Tables 4.12 ,4.14, 4.16 and 4.18) followed by the sequencing procedure (Tables 4.13, 4.15, 4.17 and 4.19)where the indicators are sequenced in an increasing order of importance. Multiplying factors were used considering the importance of indicators as per the experience and judgment of the author.

Group A

	EP1	EP2	EP3	EP4	EP5	EP7	EP10	EP11	EP12
EP1	0	1	-1	1	0	-1	1	1	1
EP2	-1	0	-1	-1	0	-1	1	1	1
EP3	1	1	0	-1	-1	-1	1	1	-1
EP4	-1	1	1	0	1	-1	1	1	1
EP5	0	0	1	-1	0	-1	0	1	-1
EP7	1	1	1	1	1	0	1	1	0
EP10	-1	-1	-1	-1	0	-1	0	-1	1
EP11	-1	-1	-1	-1	-1	-1	-1	0	-1
EP12	-1	-1	1	-1	1	0	1	1	0
sum	-3	1	0	-4	1	-7	5	6	1

Table 4.12 Pair wise comparison of EP indicators (Group A)

	EP7	EP1	EP4	EP12	EP2	EP3	EP5	EP10	EP11
f	1	1.05	1.2	1.1	1.1	1.2	1	1.3	
Weight	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 4.13 Sequencing and calculation of weights (Group A)

Group B

	EP13	EP14	EP15
EP13	0	1	1
EP14	-1	0	-1
EP15	-1	1	0
Sum	-2	2	0

Table 4.14 Pair wise comparison of EP indicators (Group B)

	EP13	EP15	EP14
f_u	1.1	1.2	
Weight	1.00	1.10	1.32

Table 4.15 Sequencing and calculation of weights (Group B)

Group C

	EP16	EP17	EP18
EP16	0	1	-1
EP17	-1	0	-1
EP18	1	1	0
Sum	0	2	-2

Table 4.16 Pair wise comparison of EP indicators (Group C)

	EP18	EP16	EP17
f_u	1.3	1.1	
Weight	1.00	1.30	1.43

Table 4.17 Sequencing and calculation of weights (Group C)

Group D

	EP19	EP20	EP21	EP22	EP23
EP19	0	-1	-1	-1	-1
EP20	1	0	1	-1	0
EP21	1	-1	0	-1	-1
EP22	1	1	1	0	1
EP23	1	0	1	-1	0
Sum	4	-1	2	-4	-1

Table 4.18 Pair wise comparison of EP indicators (Group D)

	EP22	EP20	EP23	EP21	EP19
f_u	1.2	1.1	1.2	1.3	
Weight	1.00	1.20	1.32	1.58	2.06

Table 4.19 Sequencing and calculation of weights (Group D)

After calculating the weights among the indicators within the same group of indicators, they are multiplied with the normalized values obtained for each category for all the EP indicators in the first level of analysis. Then the weighted values for each of the product category is added to and then normalized to their corresponding sum. The results are presented in tables 4.20 to 4.23

EPI		Weightage	Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
P 1	g/Unit of Product (Aver	1.00	0.053	0.106	0.106	0.691	0.044
P 2	Tons/year (2009 Volum	1.00	0.018	0.050	0.274	0.456	0.202
P 3	Recycled matter %	1.00	0.364	0.227	0.091	0.227	0.091
P 4	Effluents m^3 / Ton of pr	1.00	0.188	0.383	0.281	0.084	0.064
P 5	GHG tons/ton	1.00	0.215	0.346	0.170	0.223	0.046
P 7	Waste kg/ton of produc	1.00	0.559	0.093	0.068	0.045	0.235
P 10	Energy GJ/ton	1.00	0.125	0.352	0.212	0.288	0.023
P 11	Energy Conserved GJ/y	1.00	0.915	0.057	0.022	0.006	0.000
P 12	Water m3/ton	1.00	0.187	0.375	0.307	0.067	0.064
um			2.624	1.990	1.531	2.087	0.768
ormalized sum			0.292	0.221	0.170	0.232	0.085
Product Design)							

Table 4.20 Weighted EP indicators - Normalized values - Group A

EPI		Weightage	Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP13	Paper/Plastic Usage to	1.00	0.12	0.11	0.15	0.41	0.22
EP14	Packaging- % can be r	1.32	0.41	0.15	0.30	0.15	0.30
EP15	Waste KG/year	1.10	0.30	0.27	0.13	0.21	0.19
um			0.818	0.533	0.578	0.770	0.722
ormalized sum			0.239	0.156	0.169	0.225	0.211

Table 4.21 Weighted EP indicators - Normalized values - Group B

EPI		Weightage	Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP16	Litres/km	1.30	0.20	0.24	0.26	0.33	0.28
EP17	Litres/Million Units	1.43	0.13	0.23	0.21	0.78	0.08
EP18	Pallets/week	1.00	0.05	0.08	0.27	0.36	0.25
Sum			0.380	0.543	0.739	1.464	0.605
Normalized sum			0.102	0.145	0.198	0.392	0.162

Table 4.22 Weighted EP indicators - Normalized values - Group C

EPI		Weightage	Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
EP19	CO2/year reduction	2.06	1.75	0.19	0.09	0.03	0.00
EP20	Diesel consumption	1.20	0.12	0.52	0.16	0.14	0.26
EP21	Water Re use	1.58	0.32	0.32	0.36	0.26	0.33
EP22	Landfill	1.00	0.23	0.11	0.15	0.28	0.22
EP23	Incineration	1.32	0.20	0.46	0.15	0.16	0.36
Sum			2.200	1.031	0.603	0.425	0.584
Normalized sum			**0.454**	**0.213**	**0.125**	**0.088**	**0.121**

Table 4.23 Weighted EP indicators - Normalized values - Group D

4.7.4 Third Level of analysis

The next step is to calculate the weights y_j among the different groups of indicators. A 4 x 4 matrix is formed (Table 4.24) followed by the sequencing procedure (Table 4.25) where indicators' groups are sequenced in increasing order of importance. Multiplying factors were set by the author considering the importance of each group using the experience. Product design was given the highest weight because it contains the highest number of environmental aspects attached and has the highest environmental impact. Similarly the other groups were rated based on their impact on the environmental performance.

		Group A	Group B	Group C	Group D
Group A	Design	0	-1	-1	-1
Group B	Packaging	1	0	1	1
Group C	Logistics	1	-1	0	1
Group D	Waste Han	1	-1	-1	0
Sum		3	-3	-1	1

Table 4.24 Pair wise comparison among EP indicator groups

	Group B	Group C	Group D	Group A
f_u	1.1	1.3	1.4	
Weight	1.00	1.10	1.43	2.00

Table 4.25 pair wise comparison of groups

After having calculated the weights among the indicators' groups, they are multiplied by with the normalized sums of the groups worked out in the previous level. Then the weighted values for each product categories are added. The results expresses to what extent the product categories of soaps, powders, toothpaste, shampoo and margarine

fulfill the environmental principles that have been identified. The results are presented in Table 4.26

	Weight	Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
Group A	6.48	1.89	1.43	1.10	1.50	0.55
Group B	1.00	0.24	0.16	0.17	0.23	0.21
Group C	1.80	0.18	0.26	0.36	0.71	0.29
Group D	3.24	1.47	0.69	0.40	0.28	0.39
	12.52					
Sum		3.784	2.540	2.031	2.718	1.447
Normalized sum		0.302	0.203	0.162	0.217	0.116

Table 4.26 Aggregation and final results.

4.8 Comparison of results of two models.

The final results of the two modeling exercises carried out can be summarized as follows;

Model	Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
Tsoulfaf & Pappis	0.302	0.203	0.162	0.217	0.116
Expert Choice (Saaty's AHP)	0.306	0.223	0.150	0.208	0.113
% Difference	-1%	-9%	8%	4%	2%

Table 4.27 Comparison of results of the two models

Both the models show that soaps are having the best environmental performance and the spreads is in the other extreme. However there is a change in positions for shampoo and washing powders. This may be due to Saaty's model uses pair wise comparison at the bottom most level of the hierarchy (Assigning values to products under EP indicators) and the other model use actual data for the EP indicators. However, both the streams shows consistency as the difference is in the range of ± 10 %.

Even though the Saaty's model is having the advantage of easy interpretation and modeling, the model by Tsoulfaf & Pappis is more robust, since the actual data is used in the model. Hence the results obtained in this model will be used for final interpretation.

4.9 Summary of findings

First significant finding is that only '5' p EP indicators could be developed oppose to 18 of indicators indentified. (The n indicators were reduced to 15 subsequently) This shows the fact that the production process results in more negative impacts to the environment that the positive impacts. This very fact is an eye opener to every one in the management of USL. The message is that we should always try to mitigate the negative impacts on the environment by increasing the positive factors such as increasing the recyclability, encourage energy saving projects, reuse of water, etc.

When it comes to the EP indicators in Group A, it is clear that different products shows better performances in different individual EP indicators. The nature of the product is also a contributing factor for this. For example shampoo business is largely depends upon the sale of sachets of 5g or 7g which will use less raw material per unit compared to soaps , in which the average weight would be around 100g . Factors such as energy consumption too will depend upon the nature of the production process. For example, soaps process consumes a higher energy compared to shampoo or powders. However, the analysis prompts the management as to how to reduce the environmental impact.

Similarly the normalized values of EP indicators of groups B, C, D show the relative environment performance of each product category. Group B indicators shows soaps are having good EP compared to the rest of the products compared to the rest. Shampoo is showing a good environment performance in Logistics in group C. As far as waste handling is concerned, soaps again clearly seem to have a better environment performance.

After this analysis of individual EP indicators, the next step is to analyze the results obtained for each of the environment principle groups. Summary of the aggregated normalized values for all groups for each product category is presented in table 4.27

		Soaps	Washing Powders	Toothpaste	Shampoo	Spreads
Group A	Design	0.28	0.18	0.18	0.29	0.07
Group B	Packaging	0.24	0.16	0.17	0.23	0.21
Group C	Logistics	0.10	0.15	0.20	0.39	0.16
Group D	Waste Handeling	0.45	0.21	0.12	0.09	0.12
Sum		1.077	0.691	0.670	0.997	0.565

Table 4.28 Summary of aggregated normalized values for each group

Green, yellow and Red colors were given for product categories which does have a better, average and poor environmental performance compared to the others. In Group soaps shows a better Environmental performance (EP) largely due to the energy savings achieved during the last year by changing the soap manufacturing technology, which has got a higher weight in the pair wise comparison in section 4.5.3. Similarly shampoo is having a better EP largely due to the less material consumption and less energy consumption. On the other hand spreads shows a red due to its high energy intensive nature and high % of waste, etc. Immediate attention needs to be put on spreads and improvement opportunities should be explored for other categories.

In group B, packaging, almost all the categories shows an average performance. In this case too, soaps and shampoo's shows a marginally better EP. Therefore USL as a company should look in to minimizing the waste and increasing the use of re-cycled materials, etc across all the categories.

Logistics related EP is discussed in group C. Soaps shows a poor EP in this case largely attributable to the higher volumes transported annually and the lower fuel economy ,etc. Measures should be taken to increase the EP. Shampoo demonstrates the best due to the smaller size of the units and hence having a lower fuel usage per unit.

Finally in group D, waste handling, which is an important group, soaps demonstrates a very good EP where as shampoo shows a very poor performance. This is mainly due to

soaps saving lot of CO2 as compared to the last year and the waste generated shampoo is high compared to the volumes produced. USL should focus more on these areas to improve the environment performance in waste handling area.

In the final evaluation the overall environmental performance is demonstrated and it is evident that a special attention needs to be given in areas such as spreads (Margarine), toothpaste and powders to improve the EP. USL management should go in to more details to ascertain why certain products do well in some groups and not in others and should take corrective measures to improve these.