Life cycle sustainability assessment of a residential building project in northeast China

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PhD MPhil BSc BEAM Pro

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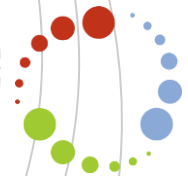

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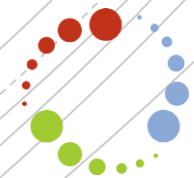
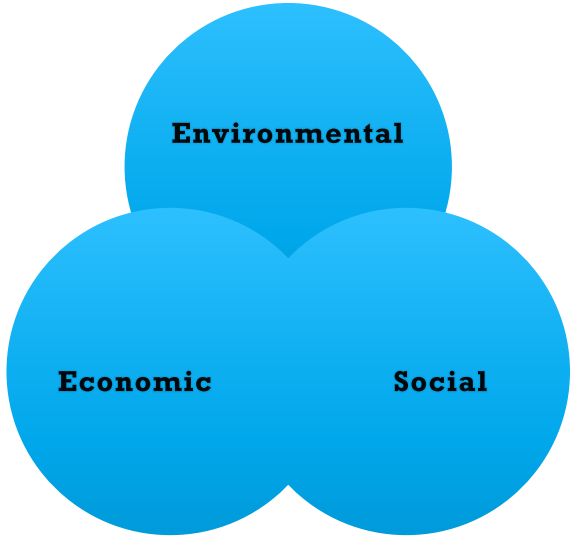
3. Case study
4. Conclusions



1. Background

Sustainable development:

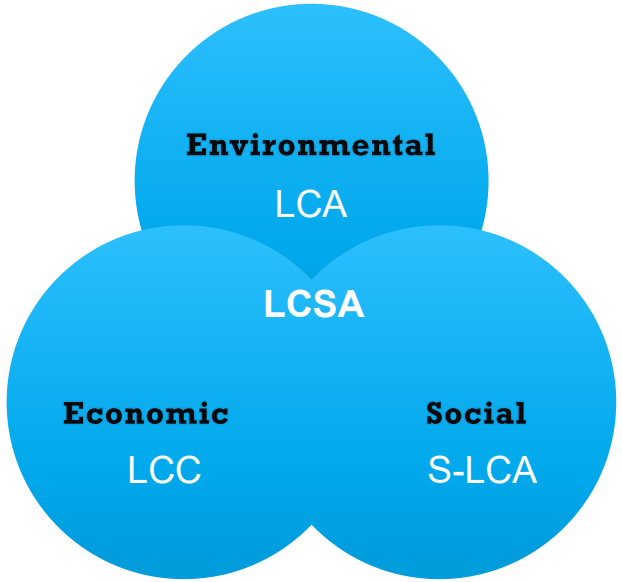
The development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. (Brundtland, 1987)



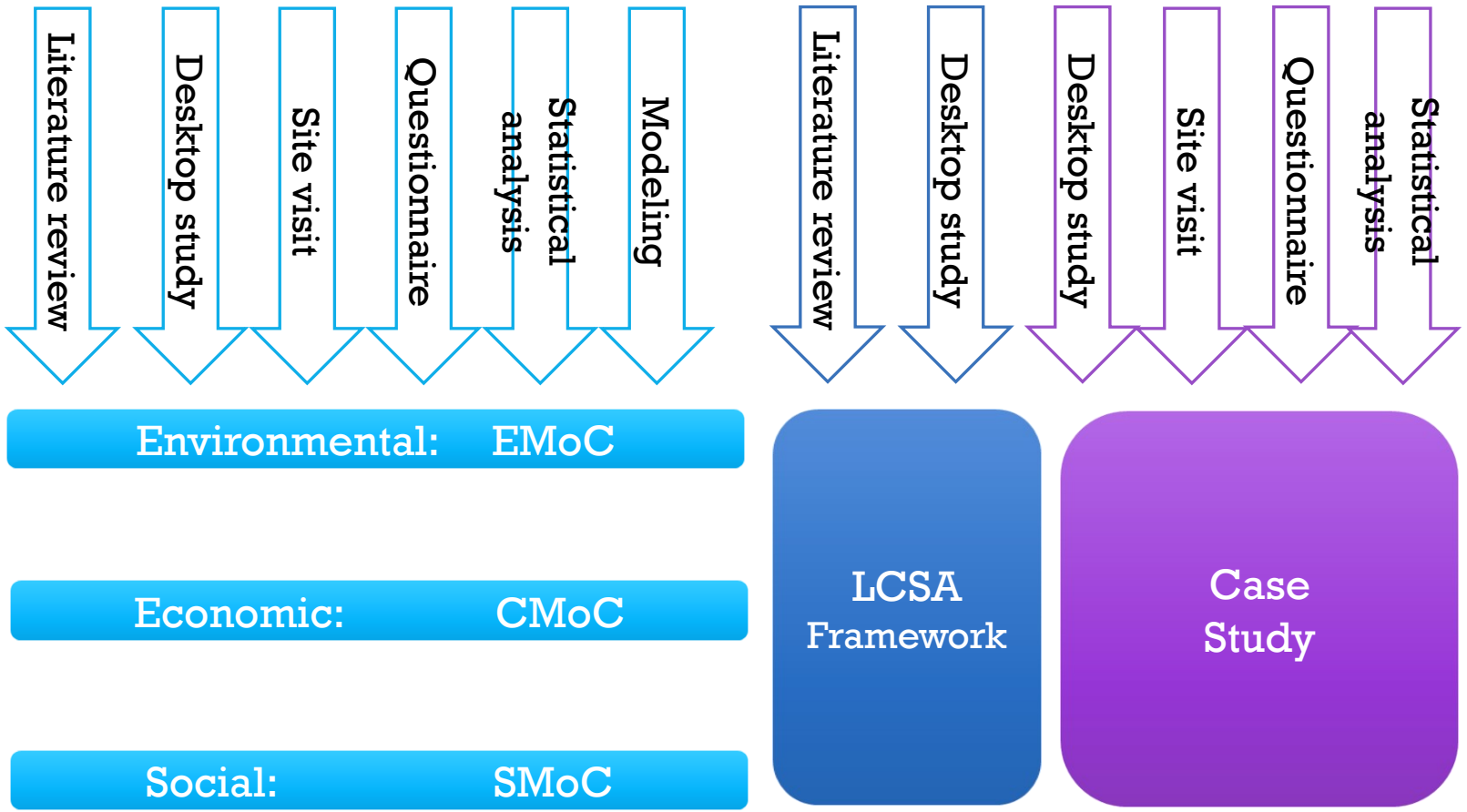
1. Background

Life cycle sustainability assessment (LCSA)

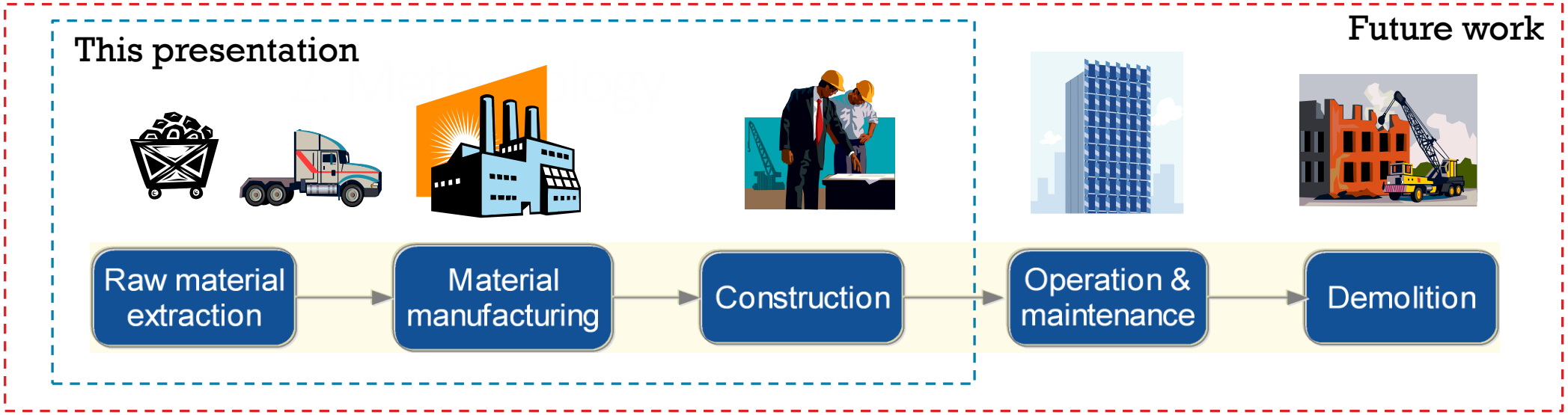
- A conceptual formula of LCSA (Kloepffer, 2008):
- **LCSA = LCA + LCC + S-LCA**
  - LCA: Environmental life cycle assessment
  - LCC: Life cycle costing
  - S-LCA: Social life cycle assessment

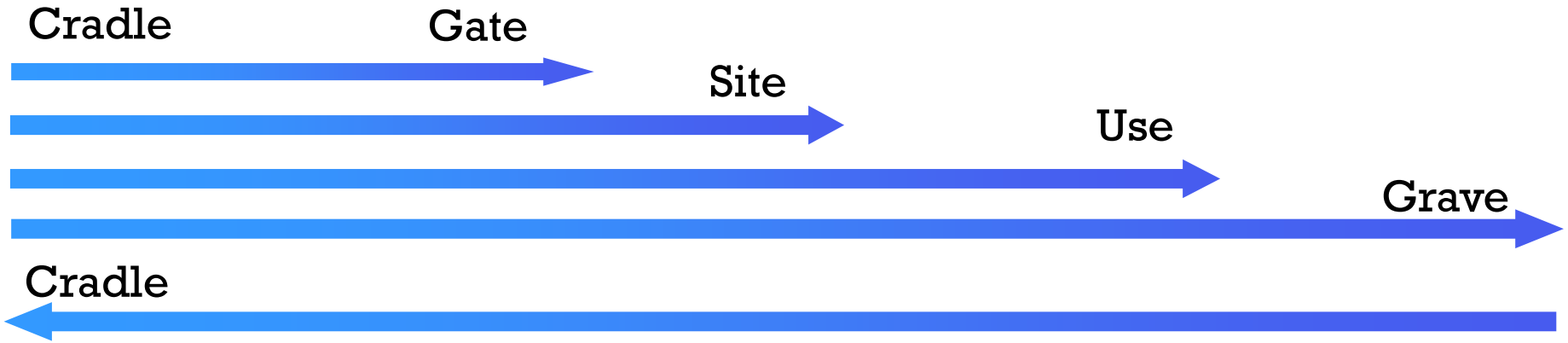


2. Methodology
Research Design



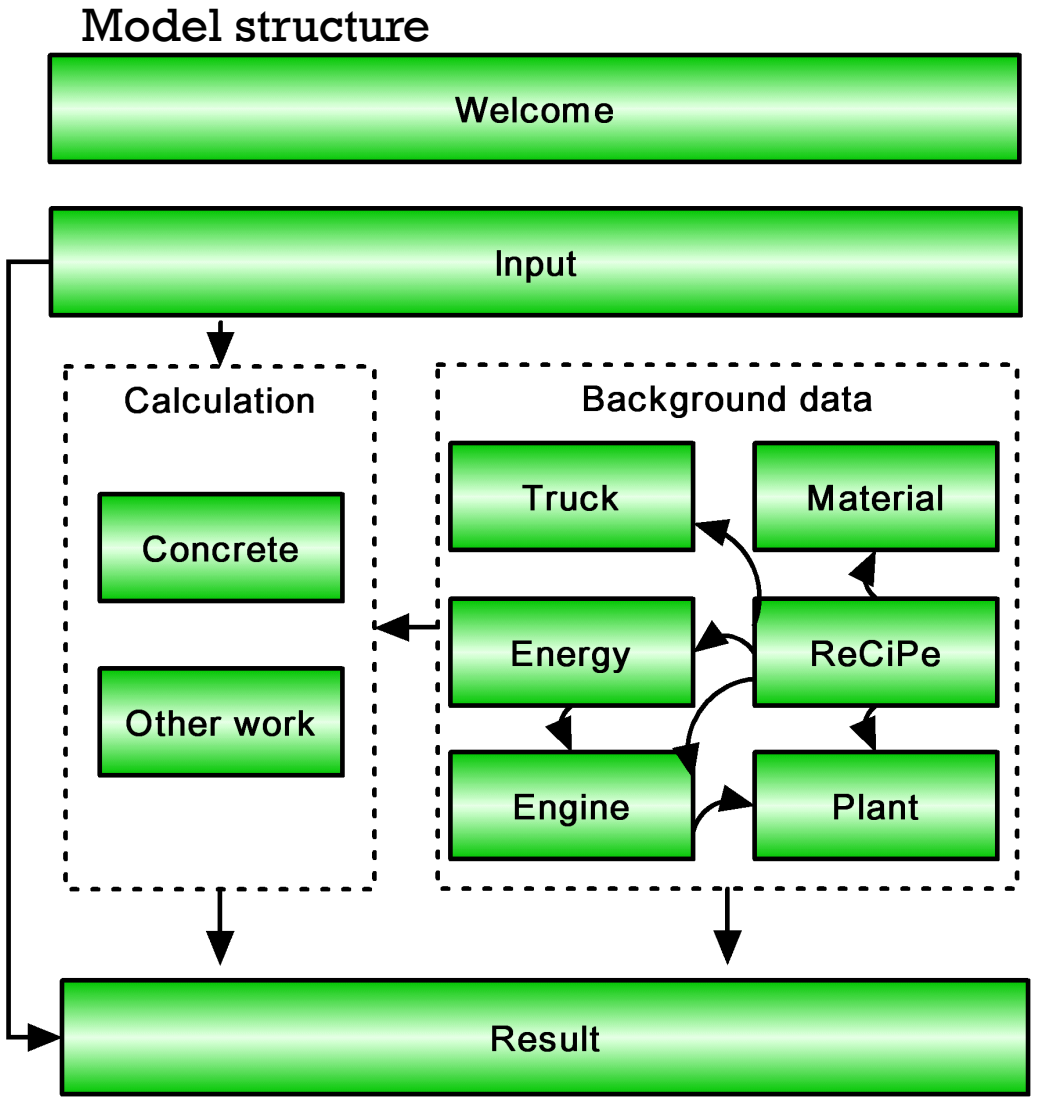
2. Methodology
Study Scope





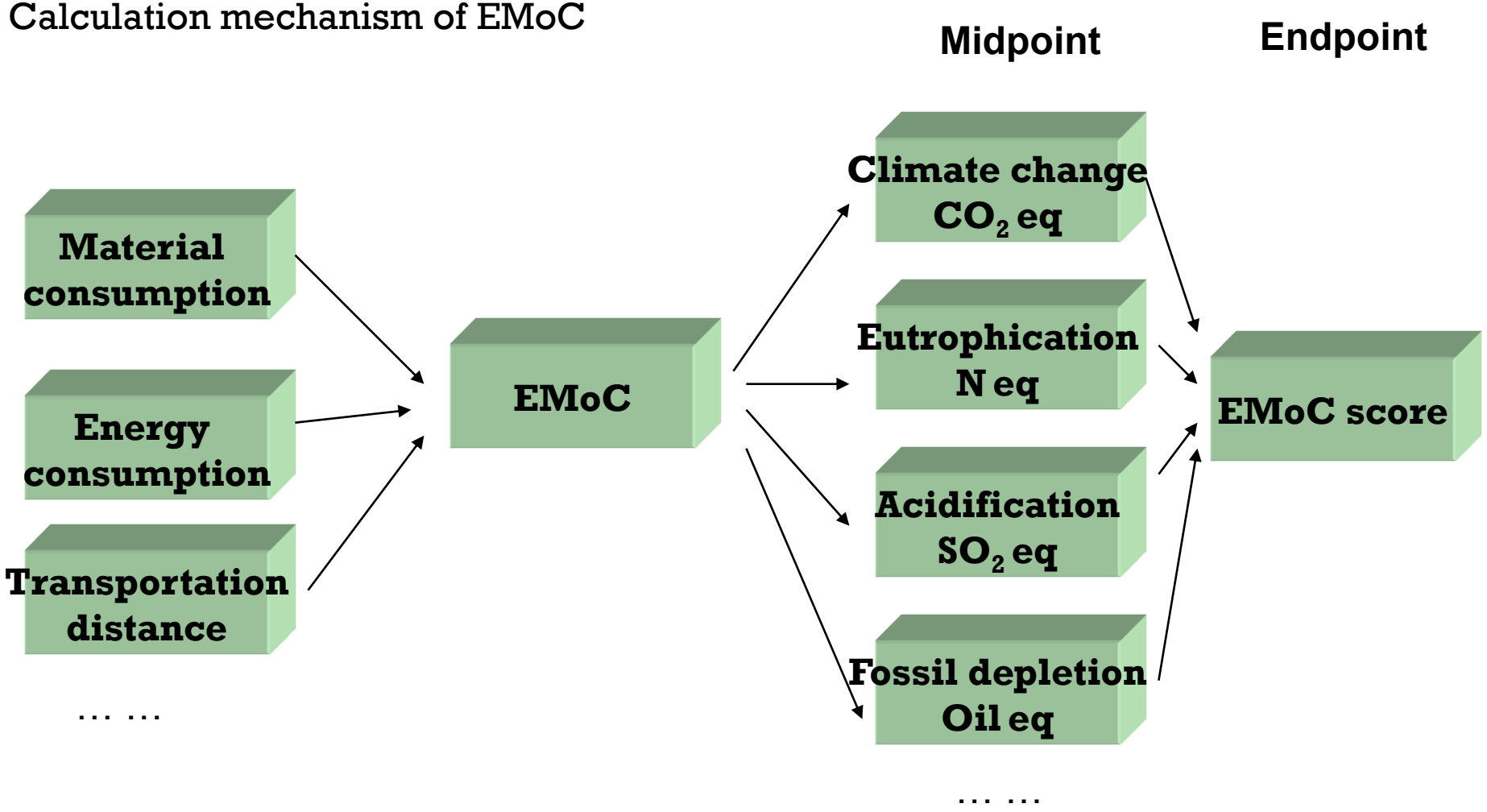
2. Methodology

Environmental Model of Construction (EMoC)



Dong et al., 2015. A life cycle assessment model for evaluating the environmental impacts of building construction in Hong Kong, Building and Environment.

Calculation mechanism of EMoC

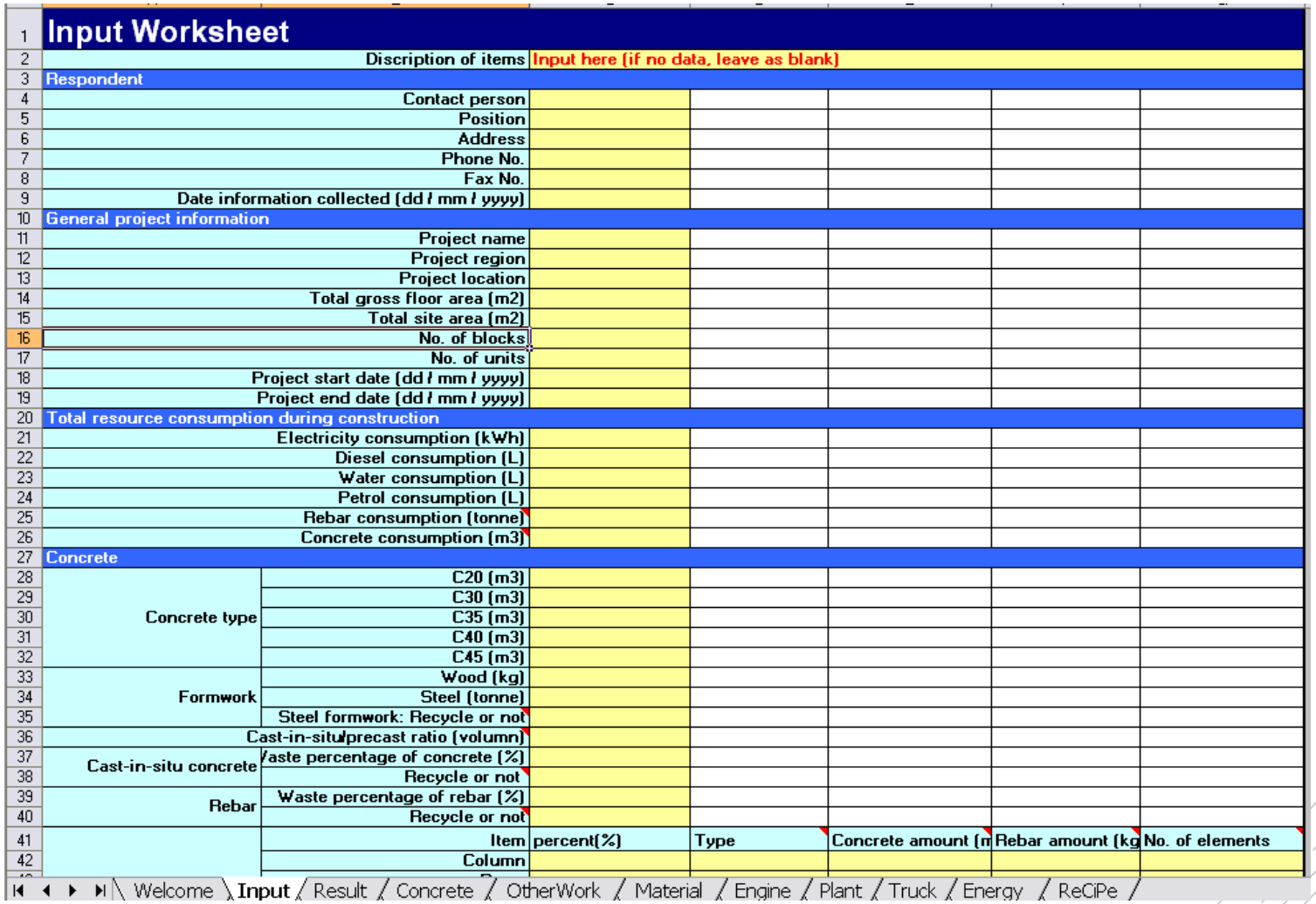


2. Methodology

Environmental Model of Construction (EMoC)

- LCIA: ReCiPe 2008
- UI: Microsoft Excel
- Size: 30 MB

Input Worksheet



1	**Input Worksheet**						
2		Discription of items	Input here (if no data, leave as blank)				
3	Respondent						
4		Contact person					
5		Position					
6		Address					
7		Phone No.					
8		Fax No.					
9		Date information collected (dd / mm / yyyy)					
10	General project information						
11		Project name					
12		Project region					
13		Project location					
14		Total gross floor area (m2)					
15		Total site area (m2)					
16		No. of blocks					
17		No. of units					
18		Project start date (dd / mm / yyyy)					
19		Project end date (dd / mm / yyyy)					
20	Total resource consumption during construction						
21		Electricity consumption (kWh)					
22		Diesel consumption (L)					
23		Water consumption (L)					
24		Petrol consumption (L)					
25		Rebar consumption (tonne)					
26		Concrete consumption (m3)					
27	Concrete						
28	Concrete type	C20 (m3)					
29		C30 (m3)					
30		C35 (m3)					
31		C40 (m3)					
32		C45 (m3)					
33	Formwork	Wood (kg)					
34		Steel (tonne)					
35		Steel formwork: Recycle or not					
36		Cast-in-situ/precast ratio (volumn)					
37	Cast-in-situ concrete	Waste percentage of concrete (%)					
38		Recycle or not					
39	Rebar	Waste percentage of rebar (%)					
40		Recycle or not					
41		Item	percent(%)	Type	Concrete amount (m	Rebar amount (kg	No. of elements
42		Column					

Welcome | Input | Result | Concrete | OtherWork | Material | Engine | Plant | Truck | Energy | ReCiPe

2. Methodology

Environmental Model of Construction (EMoC)

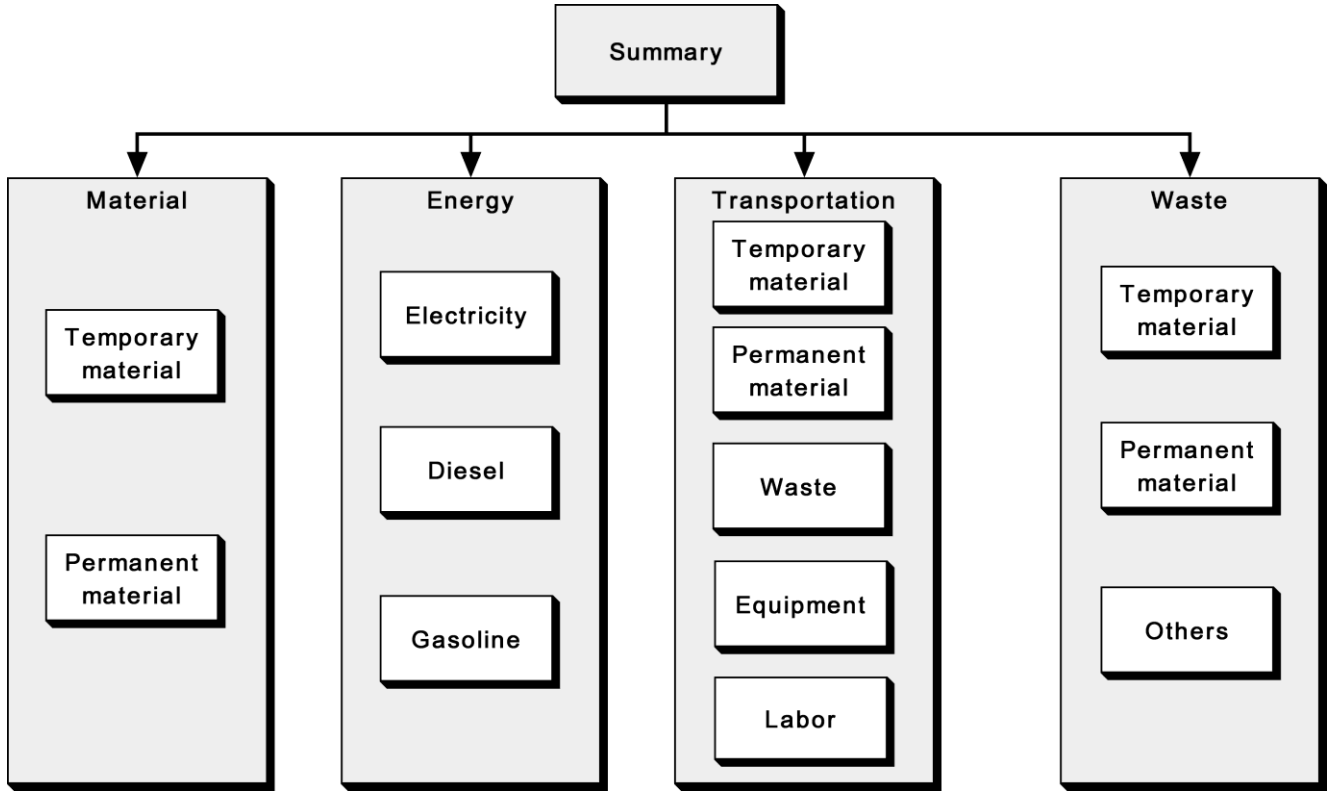
Input Worksheet

	A	B	C	D	E	F	G
43	Concrete element	Beam					
44		Façade					
45		Semi-precast slab					
46		Staircase					
47		Partition wall					
48		Balcony					
49		Bathroom					
50		Refuse chute					
51		Hanger wall					
52		Others					
53		Advantage of precast concrete					
54		)isadvantage of precast concrete					
55	Transportation						
56		Item	One way (km)	Truck model	Emission Standard		
57		Ready mix					
58		Precast					
59		Formwork					
60		Rebar					
61	Environmental protection						
62		Dust control level					
63	Other work						
64	Ground work	Concrete for piling (m3)					
65		Rebar (tonne)					
66		Excavated soil (tonne)					
67	Masonry	Item	Applied area (m2)	Item size (L*W*H	Density (kg/m2)	Waste (%)	Oneway distance (km
68		Brick					
69		Block					
70	Surface work and external	Item	Area (m2)	Amount (kg)	Waste (%)	Oneway distance	Utilization
71		Aluminium window frame					
72		inium (excluding window frame)					
73		Cement					
74		Door (wood)					
75		Glass					
76		Mortar					
77		Plaster					
78		PVC window frame					
79		Tile					
80	Equipment						
81	Machine	Type	Operation Hours	Number of equipments			
82	Excavator	Small excavator					
83		Medium excavator					
84		Large excavator					
85	Forklift	N.A.					
86		>4 tonne					

Welcome | Input | Result | Concrete | OtherWork | Material | Engine | Plant | Truck | Energy | ReCiPe

2. Methodology

Environmental Model of Construction (EMoC)



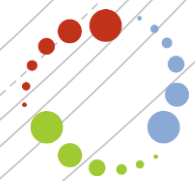
2. Methodology

Environmental Model of Construction (EMoC)

Result Worksheet

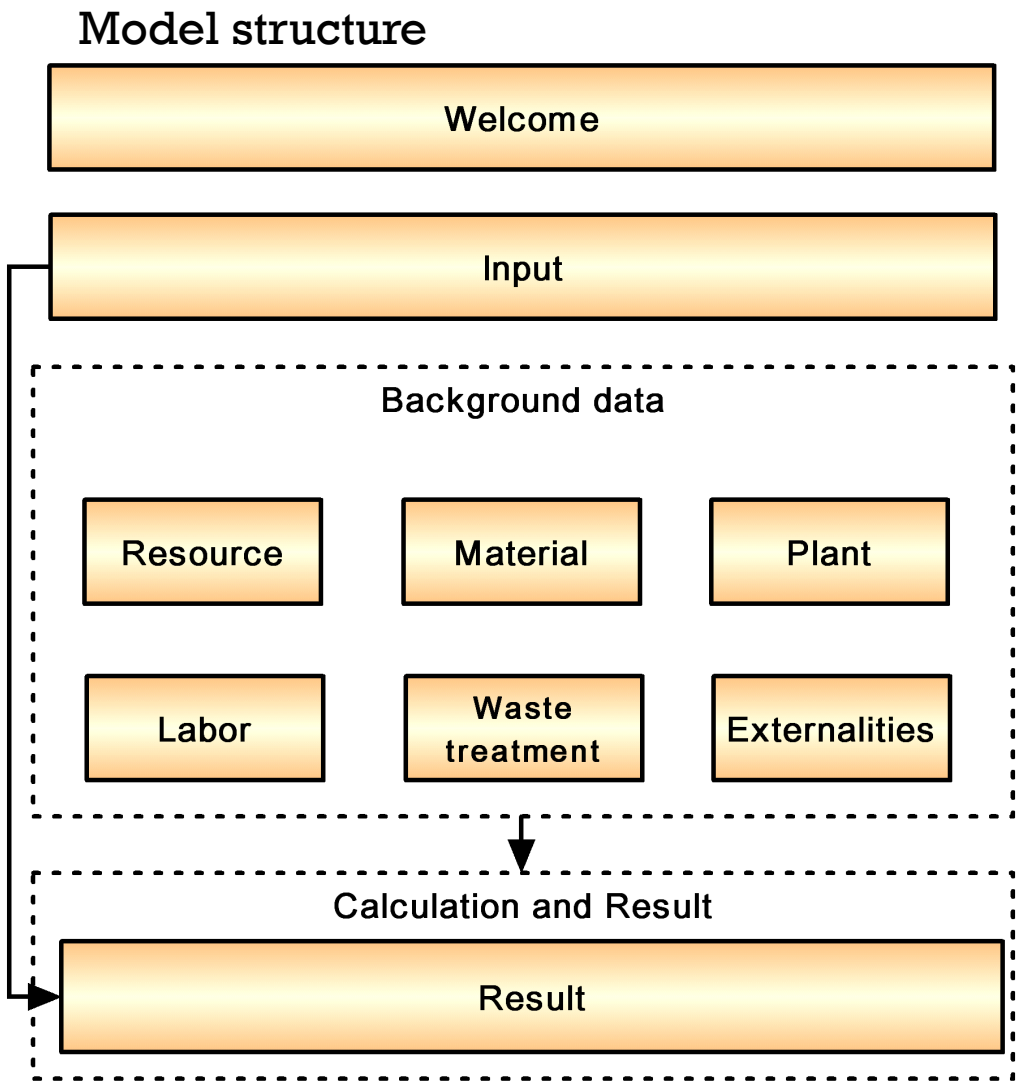
	A	B	C	D	E	F	G	H	I	J	K	L
1	**Result**											
2				Midpoint Characterization								
3	**Summary**			Climate change	Ozone depletion	Human toxicity	Photochemical oxidant formation	Particulate matter formation	Ionising radiation	Terrestrial acidification	Freshwater eutrophication	Mari eutroph n
4				kg CO2 eq	kg CFC-11 eq	kg 1,4-DB eq	kg NMVOC	kg PM10 eq	kg U235 eq	kg SO2 eq	kg P eq	kg N
5	**Material**											
6	Total			0	0	0	0	0	0	0	0	
7	Per unit			0	0	0	0	0	0	0	0	
8	Per GFA (m2)			0	0	0	0	0	0	0	0	
9	**Energy**											
10	Total			0	0	0	0	0	0	0	0	
11	Per unit			0	0	0	0	0	0	0	0	
12	Per GFA (m2)			0	0	0	0	0	0	0	0	
13	**Transportation**											
14	Total			0	0	0	0	0	0	0	0	
15	Per unit			0	0	0	0	0	0	0	0	
16	Per GFA (m2)			0	0	0	0	0	0	0	0	
17	**Waste**											
18	Total			0	0	0	0	0	0	0	0	
19	Per unit			0	0	0	0	0	0	0	0	
20	Per GFA (m2)			0	0	0	0	0	0	0	0	
21	**Dust emission**											
22	Total			0	0	0	0	0	0	0	0	
23	Per unit			0	0	0	0	0	0	0	0	
24	Per GFA (m2)			0	0	0	0	0	0	0	0	
25	**Total performance**											
26	Total			0	0	0	0	0	0	0	0	
27	Per unit			0	0	0	0	0	0	0	0	
28	Per GFA (m2)			0	0	0	0	0	0	0	0	
29												
30				Midpoint Characterization								
	Material	Amount	Unit	Climate	Ozone	Human	Photochemic al oxidant	Particulate matter	Ionising	Terrestrial	Freshwater	Mari

31	Material	Amount	Unit	Climate change	Ozone depletion	Human toxicity	Photochemical oxidant formation	Particulate matter formation	Ionising radiation
32				kg CO2 eq	kg CFC-11 eq	kg 1,4-DB eq	kg NMVOC	kg PM10 eq	kg U235 eq
33	**Material: Temporary material**								
34	Steel	0	tonne	0	0	0	0	0	0
35	Water	0	L	0	0	0	0	0	0
36	Wood	0	kg	0	0	0	0	0	0
37	**Total temporary material**			**0**	**0**	**0**	**0**	**0**	**0**
38									
39	**Material: Permenant material**								
40	**Cast in situ concrete**								
41	Column	0	m3	0	0	0	0	0	0
42	Beam	0	m3	0	0	0	0	0	0
43	Façade	0	m3	0	0	0	0	0	0
44	Semi-precast slab	0	m3	0	0	0	0	0	0
45	Staircase	0	m3	0	0	0	0	0	0
46	Partition wall	0	m3	0	0	0	0	0	0
47	Balcony	0	m3	0	0	0	0	0	0
48	Bathroom	0	m3	0	0	0	0	0	0
49	Refuse chute	0	m3	0	0	0	0	0	0
50	Hanger wall	0	m3	0	0	0	0	0	0
51	Pile	0	m3	0	0	0	0	0	0
52	Others	0	m3	0	0	0	0	0	0
53	**Total cast in situ concrete**	**0**	**m3**	**0**	**0**	**0**	**0**	**0**	**0**
54	**Precast concrete**								
55	Column	0	m3	0	0	0	0	0	0
56	Beam	0	m3	0	0	0	0	0	0
57	Façade	0	m3	0	0	0	0	0	0
58	Semi-precast slab	0	m3	0	0	0	0	0	0
59	Staircase	0	m3	0	0	0	0	0	0
60	Partition wall	0	m3	0	0	0	0	0	0

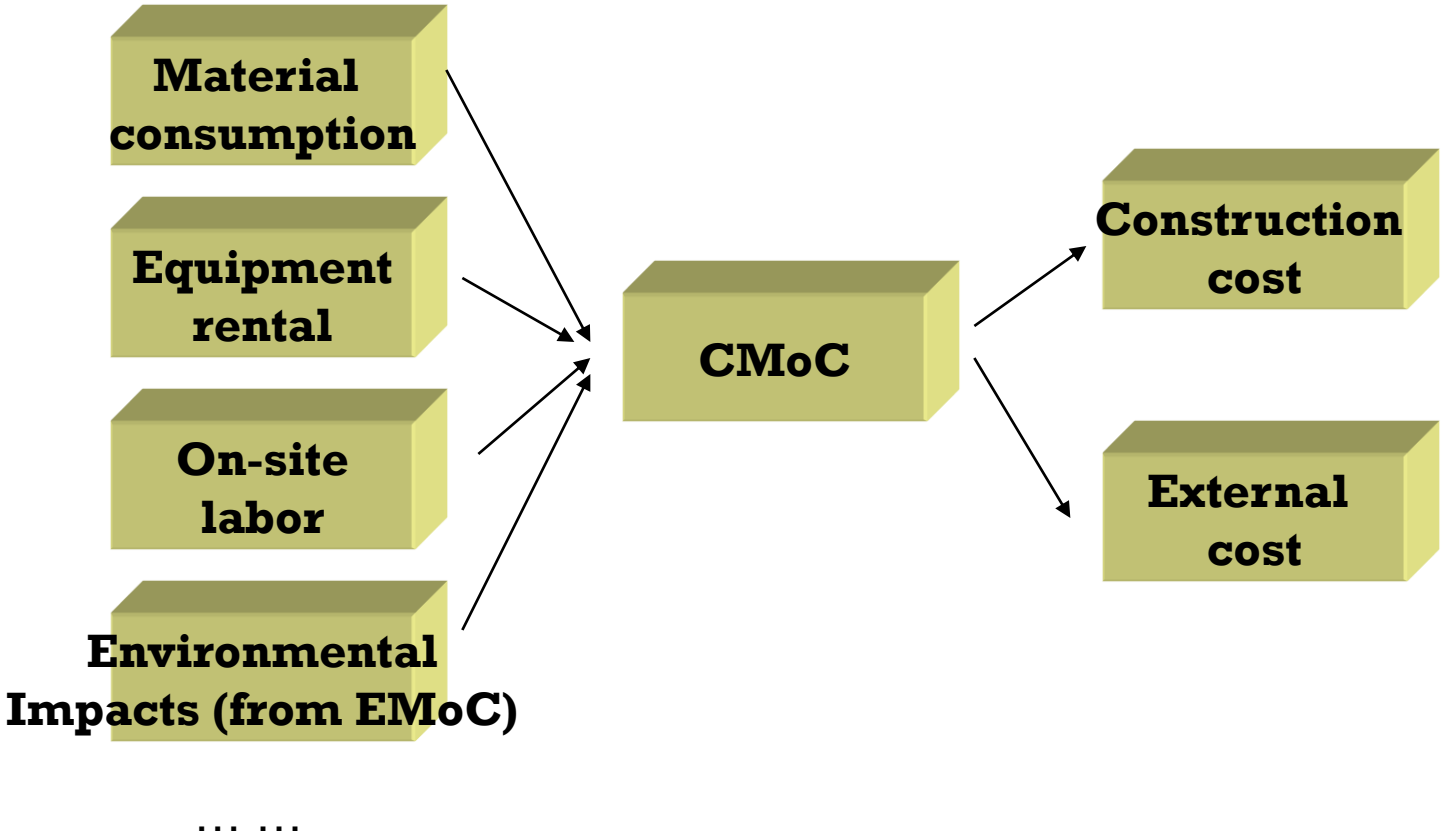


2. Methodology

Cost Model of Construction (CMoC)



Calculation mechanism of CMoC



2. Methodology

Cost Model of Construction (CMoC)

Input Worksheet		
	Discription of items	Input here (if no data, leave as blank)
Respondent		
	Contact person	
	Position	
	Address	
	Phone No.	
	Fax No.	
	Date information collected (dd / mm / yyyy)	
General project information		
	Project name	
	Project region	
	Project location	
	Total gross floor area (m2)	
	Total site area (m2)	
	No. of blocks	
	No. of units	
	Project start date (dd / mm / yyyy)	
	Project end date (dd / mm / yyyy)	
Total resource consumption during construction		
	Electricity consumption (kWh)	
	Diesel consumption (L)	
	Petrol consumption (L)	
	Water consumption (L)	
Material and component		
Foundation and Substructure	Piling	
	Substructure	
Carcase	Frame and slabs	
	External walls	
	Internal walls	
	Doors and shutters	
	Windows	
	Glazed screens	
	Shop fronts	
	Skylights	
Finishings	Roof finishes	
	Floor finishes	
	Internal wall finishes	
	Ceiling finishes	
	External wall finishes	
	Décor, graphics and signage	
Furniture and Fittings	Metal works and sundries	
	Built-in furniture	
	Kitchen appliances	
Services	Sanitary fittings	
	Plumbing and disposal	
	Fire services	
	Electrical	
	Security	
	MVAC	
	Lifts	
	Gas	
	Communication	

2. Methodology

Cost Model of Construction (CMoC)

Results	
Summary	**Cost (HK$)**
Material	
Total	0
Per unit	0
Per GFA (m2)	0
Resource	
Total	0
Per unit	0
Per GFA (m2)	0
Plant	
Total	0
Per unit	0
Per GFA (m2)	0
Labor	
Total	0
Per unit	0
Per GFA (m2)	0
Waste	
Total	0
Per unit	0
Per GFA (m2)	0
External	
Total	0
Per unit	0
Per GFA (m2)	0
Total performance	
Total	0
Per unit	0
Per GFA (m2)	0

Resource	Amount		Cost (HK$)
Electricity	0	kWh	0
Diesel	0	L	0
Gasoline	0	L	0

2. Methodology

Social-impact Model of Construction (SMoC)

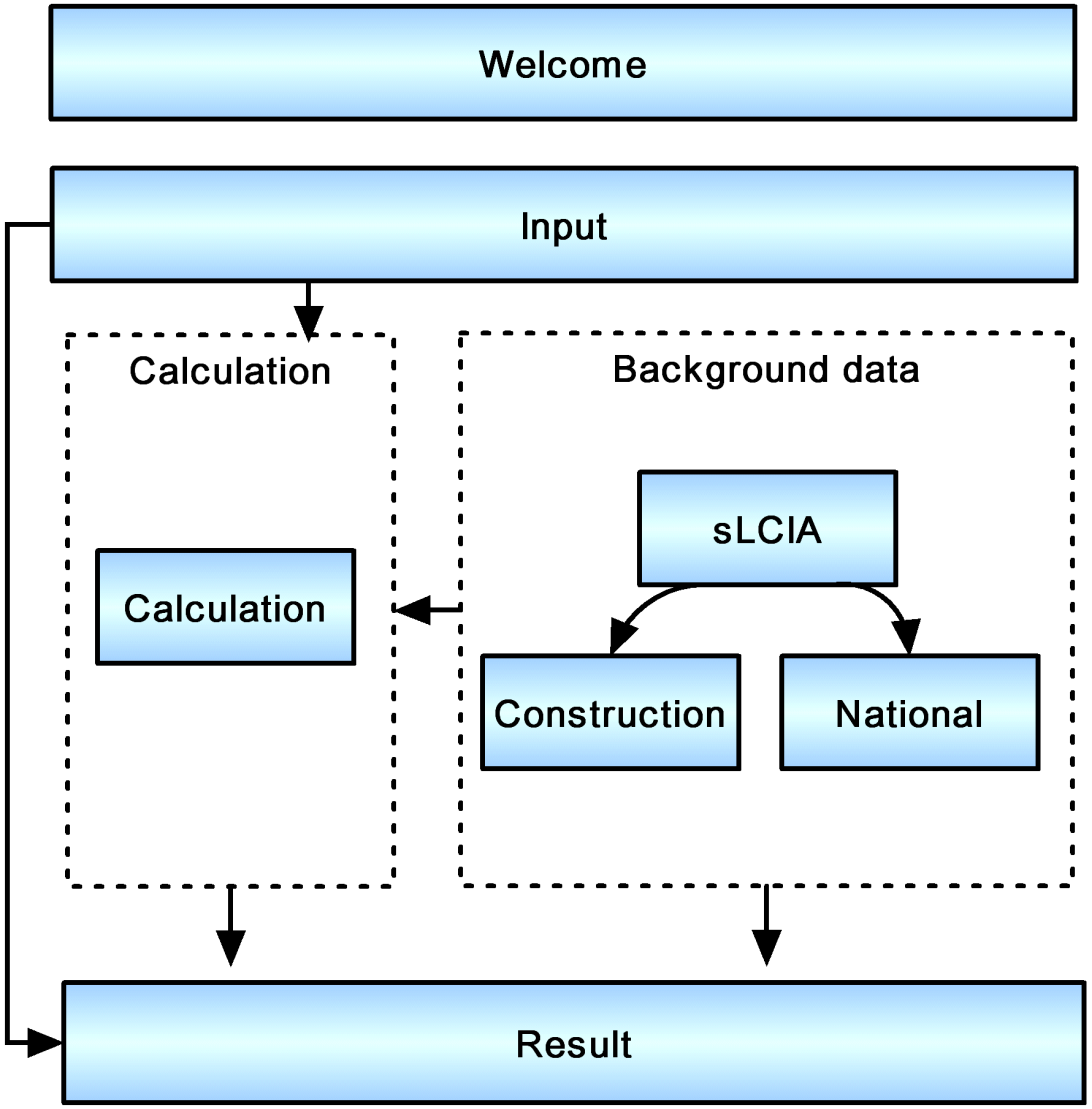
- ❑ Microsoft Excel
- ❑ 7 functional worksheets
- ❑ sLCIA method is used in SMoC
- ❑ Social impacts of on-site practices collected from questionnaire survey are applied as background data in 'Construction Worksheet'

Dong and Ng, 2015. A social life cycle assessment model for building construction in Hong Kong, *International Journal of Life Cycle Assessment.*

2. Methodology

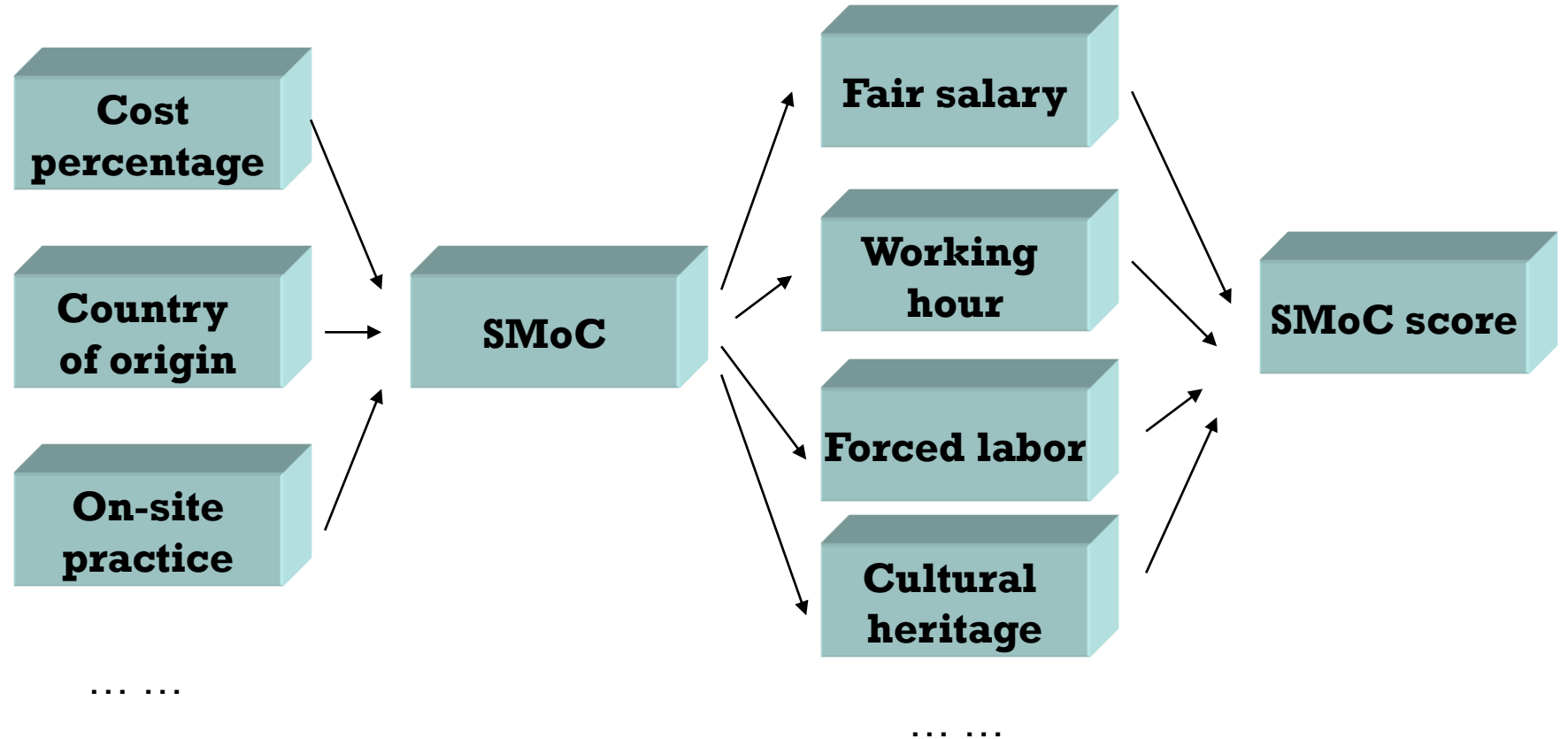
Social-impact Model of Construction (SMoC)

Model structure



Social-impact Model of Construction (SMoC)

Calculation mechanism of SMoC



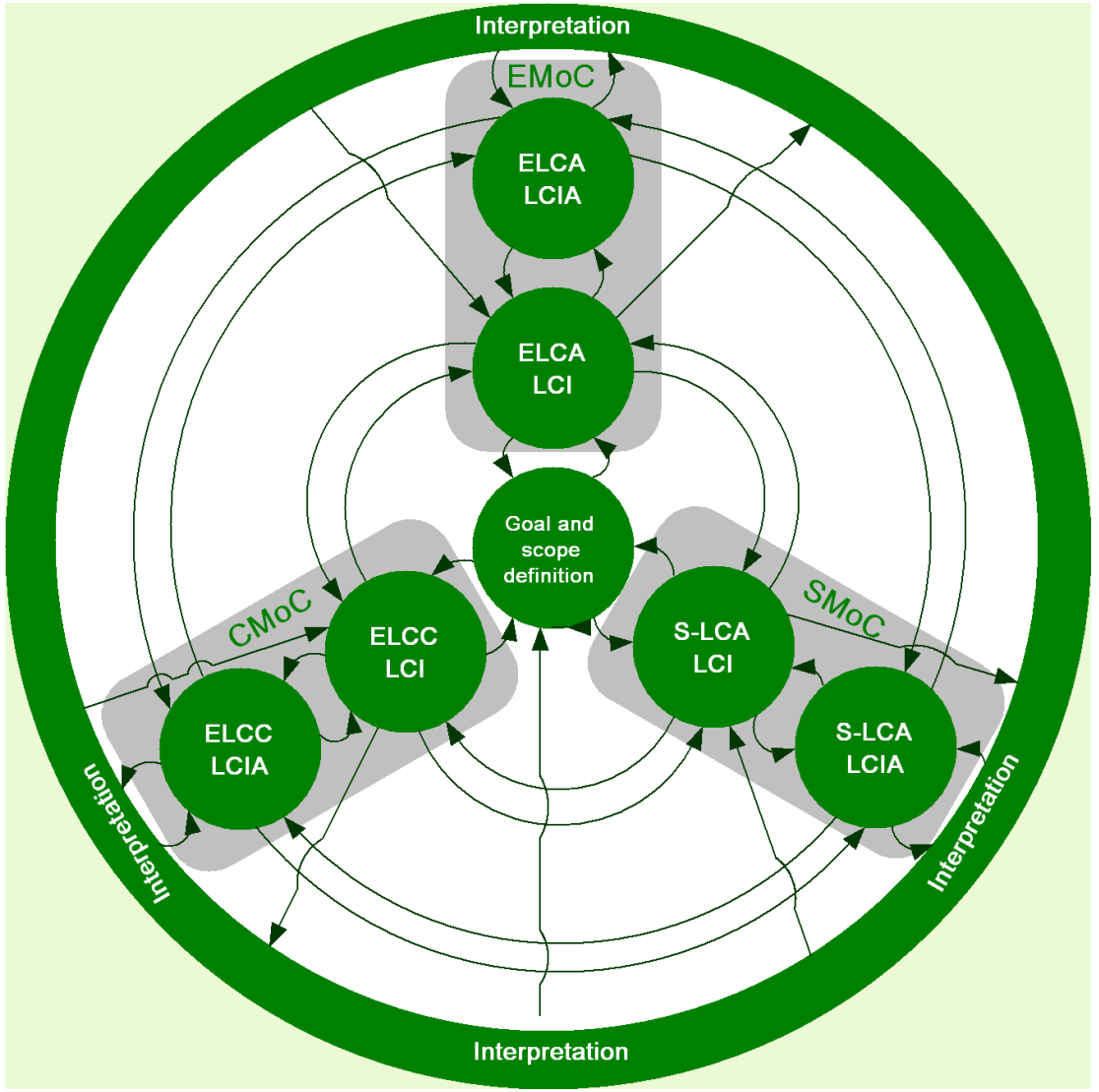
2. Methodology

Social-impact Model of Construction (SMoC)

Input Worksheet					
Discription of items	Input here (if no data, leave as blank)				
Respondent					
Contact person					
Position					
Address					
Phone No.					
Fax No.					
Date information collected (dd / mm / yyyy)					
General project information					
Project name					
Project region					
Project location					
Total gross floor area (m2)					
Total site area (m2)					
No. of blocks					
No. of units					
Project start date (dd / mm / yyyy)					
Project end date (dd / mm / yyyy)					
Total resource consumption during construction					
Item	Cost%	Country of origin			
Electricity					
Diesel					
Petrol					
Water					
Material and component					
Material	Cost%	Country of origin			
Foundation and substructure					
Piling					
Substructure					
Carcase					
Frame and slabs					
External walls					
Internal walls					
Doors and shutters					
Windows					
Glazed screens					
Shop fronts					
Skylights					
Finishes					
Roof finishes					
Floor finishes					
Internal wall finishes					
Ceiling finishes					
External wall finishes					
Décor, graphics and signage					
Furnish and fitting					
Metal works and sundries					
Built-in furniture					
Kitchen appliances					
Services					
Sanitary fittings					
Plumbing and disposal					

2. Methodology

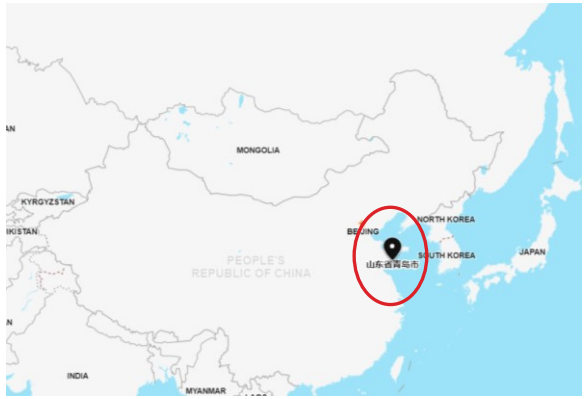
LCSA Framework



Dong, Y. H., & Ng, S. T. (2016). A modeling framework to evaluate sustainability of building construction based on LCSA. *The international journal of life cycle assessment*, *21*(4), 555-568.

2. Case Study

Building type: residential building
Location: Qingdao, China

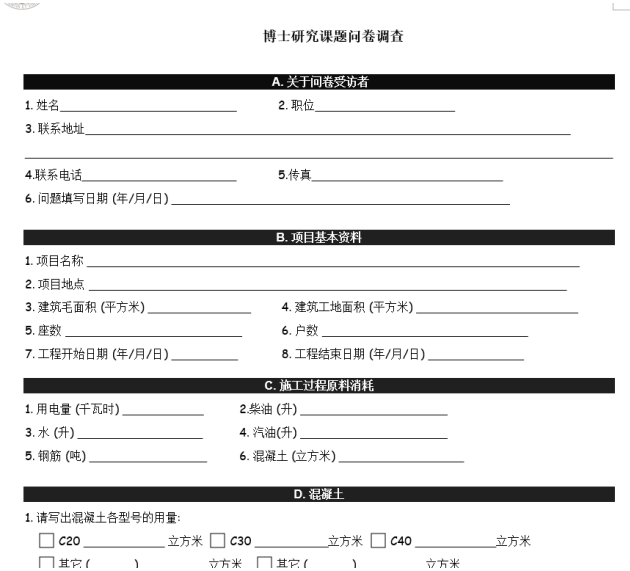


Construction area: 35,000 m^2
No. of apartments: 204
No. of towers: 2

3. Case study

Data collection

- Data are collected through a questionnaire.
- Several rounds of consultation were carried out to collect more information.



博士研究课题问卷调查

A. 关于问卷受访者

1. 姓名_____ 2. 职位_____
3. 联系地址_____
4.联系电话_____ 5.传真_____
6. 问题填写日期 (年/月/日) _____

B. 项目基本资料

1. 项目名称 _____
2. 项目地点 _____
3. 建筑毛面积 (平方米) _____ 4. 建筑工地面积 (平方米) _____
5. 座数 _____ 6. 户数 _____
7. 工程开始日期 (年/月/日) _____ 8. 工程结束日期 (年/月/日) _____

C. 施工过程原料消耗

1. 用电量 (千瓦时) _____ 2.柴油 (升) _____
3. 水 (升) _____ 4. 汽油(升) _____
5. 钢筋 (吨) _____ 6. 混凝土 (立方米) _____

D. 混凝土

1. 请写出混凝土各型号的用量:

☐ C20 _____立方米 ☐ C30 _____立方米 ☐ C40 _____立方米

☐ 其它 (　　) _____立方米 ☐ 其它 (　　) _____立方米

5. 混凝土件

混凝土件	*方法	混凝土型号	**混凝土总量 (平方米)	**钢筋 (千克)	混凝土件的数量 (个)
柱	现浇 _____% 预制 _____%				
梁	现浇 _____% 预制 _____%				
外墙	现浇 _____% 预制 _____%				
板	现浇 _____% 预制 _____%				
楼梯	现浇 _____% 预制 _____%				
间隔墙	现浇 _____% 预制 _____%				
阳台	现浇 _____% 预制 _____%				
浴室	现浇 _____% 预制 _____%				
其它:	现浇 _____% 预制 _____%				
其它:	现浇 _____% 预制 _____%				
其它:	现浇 _____% 预制 _____%				
其它:	现浇 _____% 预制 _____%				

* 体积百分比.
** 混凝土总量，是指，例如. 该项目所有柱所用的混凝土量.

6. 预制混凝土在什么方面可以减少建筑工程的环境影响:

☐ 废料减少 ☐ 噪声减少 ☐ 物料减少 ☐ 其它: _____

7. 使用预制混凝土的缺点有: _____

Input data

Table 3
Data collection of the residential building project.

Stage	Module	Item	Amount	Unit	Source
Product	A1-A3	Concrete	19,000	m^3	Project manager
		Brick	5,200	kg	Project manager
		Aluminum	12,000	m^2	Project manager
		Cement	60,000	kg	Project manager
		Plaster	15,000	kg	Project manager
		Steel	2,750	Ton	Project manager
Construction	A4	Transport ready mix	5	Km	Project manager
		Transport steel	10	Km	Project manager
		Transport brick	25	Km	Project manager
	A5	Electricity	225,000	Kwh	Project manager
		Diesel	1,000	L	Project manager
		Water	20,000,000	L	Project manager
		Gasoline	6,800	L	Project manager
Use	B6	Electricity	188.4	kWh/p*yr	National Bureau of Statistics
		Natural gas	20	m^3/household*m	National Bureau of Statistics
	B7	Water	181	L/p*day	Ministry of Water Resources

5

Dong, Y., Liu, P., Hossain, M. U., Fang, Y., He, Y., & Li, H. (2021). An Index of Completeness (IoC) of life cycle assessment: Implementation in the building sector. *Journal of Cleaner Production*, 283, 124672.

Model Results- Environmental Impacts

Result

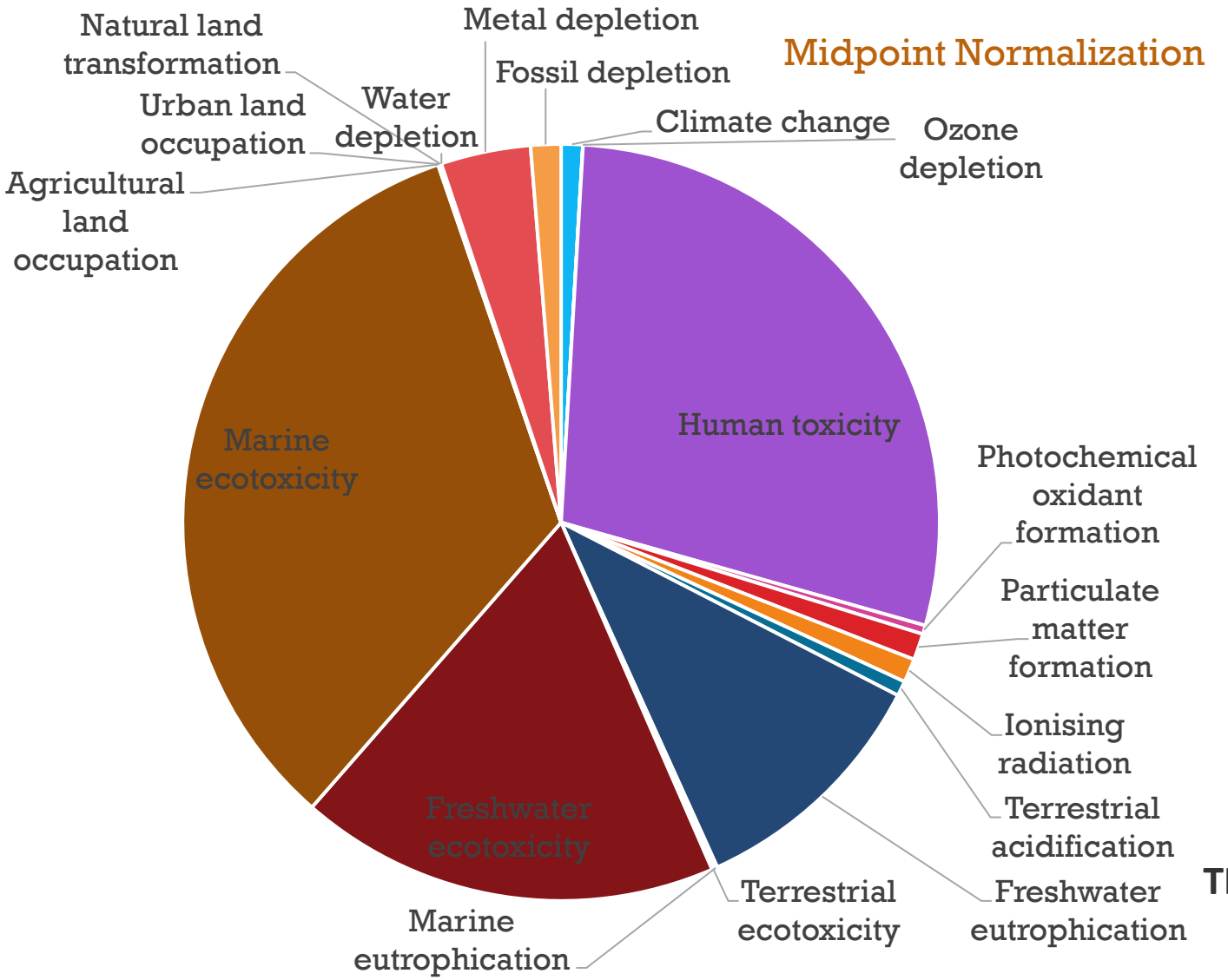
Summary	Midpoint Characterization																		Midpoint
	Climate change	Ozone depletion	Human toxicity	Photochemical oxidant formation	Particulate matter formation	Ionising radiation	Terrestrial acidification	Freshwater eutrophication	Marine eutrophication	Terrestrial ecotoxicity	Freshwater ecotoxicity	Marine ecotoxicity	Agricultural land occupation	Urban land occupation	Natural land transformation	Water depletion	Metal depletion	Fossil depletion	Clima chang
	kg CO2 eq	kg CFC-11 eq	kg 1,4-DB eq	kg NMVOC	kg PM10 eq	kg U235 eq	kg SO2 eq	kg P eq	kg N eq	kg 1,4-DB eq	kg 1,4-DB eq	kg 1,4-DB eq	m2a	m2a	m2	m3	kg Fe eq	kg oil eq	
Material																			
Total	9854033.796	0.52124771	5323599.684	28157.81663	24294.32667	2149764.995	36966.59976	4948.066583	1640.463273	1042.464987	124441.915	128467.6151	157099.1121	60991.89367	1561.622239	92291.14246	2746232.71	2771482.82	1429.8
Per unit	48304.08723	0.002555136	26096.07688	138.0285129	119.0898366	10538.0637	181.2088224	24.25522835	8.041486631	5.110122485	610.0093871	629.7432115	770.0936868	298.9798709	7.655010977	452.4075611	13461.92505	13585.7001	7.0089
Per GFA (m2)	281.5438227	1.48928E-05	152.1028481	0.804509047	0.694123619	61.421857	1.056188565	0.141373331	0.046870379	0.029784714	3.555483285	3.67050329	4.48854606	1.742625533	0.044617778	2.636889785	78.46379173	79.18522343	0.0408
Energy																			
Total	291138.2349	0.00043813	52382.57862	1390.074549	762.4449133	770.4693039	2340.498317	30.60210768	53.67453322	5.822933525	774.3884617	773.8544028	7035.698842	2053.121637	38.37370307	683.0868665	1141.172673	70595.94396	42.244
Per unit	1427.14821	2.1477E-06	256.7773462	6.814090925	3.737475065	3.776810313	11.47303096	0.150010332	0.263110457	0.028543792	3.796021871	3.793403935	34.48871981	10.06432175	0.188106388	3.348465032	5.593983693	346.0585488	0.2070
Per GFA (m2)	8.318235282	1.2518E-08	1.496645103	0.039716416	0.02178414	0.022013409	0.06687138	0.000874346	0.001533558	0.00016637	0.022125385	0.022110126	0.201019967	0.058660618	0.001096392	0.019516768	0.032604934	2.01702697	0.0012
Transportation																			
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Per unit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Per GFA (m2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Waste																			
Total	19533.62432	0.005853126	1895.919113	215.7452163	57.0337247	1798.965167	121.2033564	1.543226912	6.998373054	2.238722146	46.48225795	44.86502445	675.9285638	2742.63808	-110.9917812	470.4123875	724.9300057	12434.41825	2.8343
Per unit	95.75306038	2.86918E-05	9.293721142	1.05757459	0.279577082	8.818456703	0.5941341	0.007564838	0.03430575	0.010974128	0.227854206	0.21992659	3.313375313	13.44430431	-0.544077359	2.305943076	3.553578459	60.95303063	0.0138
Per GFA (m2)	0.558103552	1.67232E-07	0.054169118	0.006164149	0.001629535	0.051399005	0.003462953	4.40922E-05	0.000199954	6.39635E-05	0.001328065	0.001281858	0.019312245	0.078361088	-0.003171194	0.013440354	0.020712286	0.355269093	8.0980
Dust emission																			
Total	0	0	0	0	414.2119014	0	0	0	0	0	0	0	0	0	0	0	0	0	
Per unit	0	0	0	0	2.030450497	0	0	0	0	0	0	0	0	0	0	0	0	0	
Per GFA (m2)	0	0	0	0	0.011834626	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total performance																			
Total	10164705.65	0.527538967	5377878.182	29763.6364	25528.01721	2152334.429	39428.30144	4980.211917	1701.136179	1050.526643	125262.7857	129286.3346	164810.7395	65787.65339	1489.004161	93444.64171	2748098.813	2854513.182	1474.8
Per unit	49826.9885	0.002585975	26362.14795	145.9001784	125.1373393	10550.65897	193.2759874	24.41280352	8.338902838	5.149640405	614.0332632	633.756542	807.8957819	322.488497	7.299040006	458.0619692	13471.07261	13992.71168	7.2298
Per GFA (m2)	290.4201616	1.50725E-05	153.6536623	0.850389611	0.72937192	61.49526941	1.126522898	0.142291769	0.048603891	0.030015047	3.578936734	3.693895273	4.708878272	1.87964724	0.042542976	2.669846906	78.51710895	81.55751949	0.0421

Material	Amount	Unit	Midpoint Characterization																Midpoint
			Climate change	Ozone depletion	Human toxicity	Photochemical oxidant formation	Particulate matter formation	Ionising radiation	Terrestrial acidification	Freshwater eutrophication	Marine eutrophication	Terrestrial ecotoxicity	Freshwater ecotoxicity	Marine ecotoxicity	Agricultural land occupation	Urban land occupation	Natural land transformation	Water depletion	Metal depletion	Fossil depletion	Clima chang
			kg CO2 eq	kg CFC-11 eq	kg 1,4-DB eq	kg NMVOC	kg PM10 eq	kg U235 eq	kg SO2 eq	kg P eq	kg N eq	kg 1,4-DB eq	kg 1,4-DB eq	kg 1,4-DB eq	m2a	m2a	m2	m3	kg Fe eq	kg oil eq	
Material: Temporary material																					
Steel	0	tonne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Water	2E+07	L	3328.893678	0.000271876	2743.080953	10.83961033	5.970691615	6700.707102	12.46296695	1.903480741	0.724193169	1.093064784	82.54085718	51.09534387	403.4111884	290.0430363	1.81867865	22641.0984	387.5176197	818.0330712	0.4830
Wood	0	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total temporary material			**3328.893678**	**0.000271876**	**2743.080953**	**10.83961033**	**5.970691615**	**6700.707102**	**12.46296695**	**1.903480741**	**0.724193169**	**1.093064784**	**82.54085718**	**51.09534387**	**403.4111884**	**290.0430363**	**1.81867865**	**22641.0984**	**387.5176197**	**818.0330712**	**0.4830**
Material: Permenant material																					

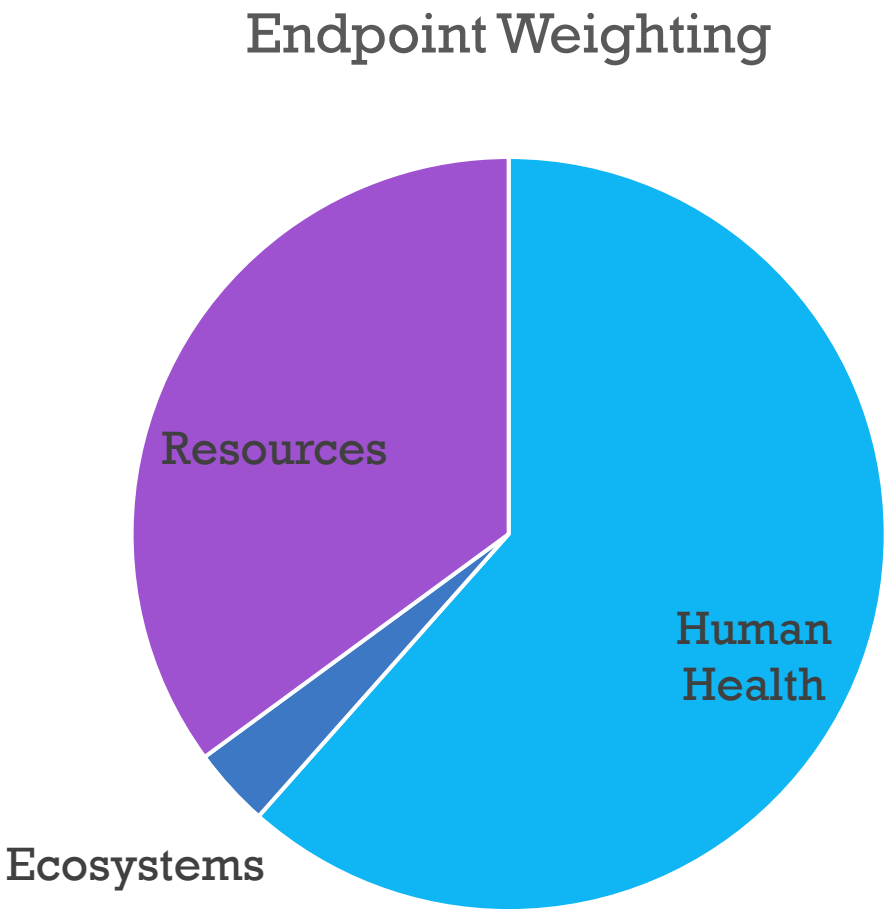
Model Results- Environmental Impacts Midpoint Characterization

		Material	Energy	Waste	Total
Impact Category	Unit	Per GFA (m2)	Per GFA (m2)	Per GFA (m2)	Per GFA (m2)
Climate change	kg CO2 eq	281.5438227	8.318235282	0.558103552	**290.4202**
Ozone depletion	kg CFC-11 eq	1.48928E-05	1.2518E-08	1.67232E-07	1.51E-05
Human toxicity	kg 1,4-DB eq	152.1028481	1.496645103	0.054169118	153.6537
Photochemical oxidant formation	kg NMVOC	0.804509047	0.039716416	0.006164149	0.85039
Particulate matter formation	kg PM10 eq	0.694123619	0.02178414	0.001629535	0.729372
Ionising radiation	kg U235 eq	61.421857	0.022013409	0.051399005	61.49527
Terrestrial acidification	kg SO2 eq	1.056188565	0.06687138	0.003462953	1.126523
Freshwater eutrophication	kg P eq	0.141373331	0.000874346	4.40922E-05	0.142292
Marine eutrophication	kg N eq	0.046870379	0.001533558	0.000199954	0.048604
Terrestrial ecotoxicity	kg 1,4-DB eq	0.029784714	0.00016637	6.39635E-05	0.030015
Freshwater ecotoxicity	kg 1,4-DB eq	3.555483285	0.022125385	0.001328065	3.578937
Marine ecotoxicity	kg 1,4-DB eq	3.67050329	0.022110126	0.001281858	3.693895
Agricultural land occupation	m2a	4.48854606	0.201019967	0.019312245	4.708878
Urban land occupation	m2a	1.742625533	0.058660618	0.078361088	1.879647
Natural land transformation	m2	0.044617778	0.001096392	-0.003171194	0.042543
Water depletion	m3	2.636889785	0.019516768	0.013440354	2.669847
Metal depletion	kg Fe eq	78.46379173	0.032604934	0.020712286	78.51711
Fossil depletion	kg oil eq	79.18522343	2.01702697	0.355269093	81.55752

Model Results- Environmental Impacts Midpoint Normalization



Model Results- Environmental Impacts Endpoint Weighting



Model Results- Economic Impacts

Construction cost: 3939 RMB/m2 (609USD/m2)

External cost:

External	Cost (USD)
Human health	6.10E+11
Ecosystem	4.47E+15
Resource depletion	3.94E+04
Total external cost:	4.47E+15

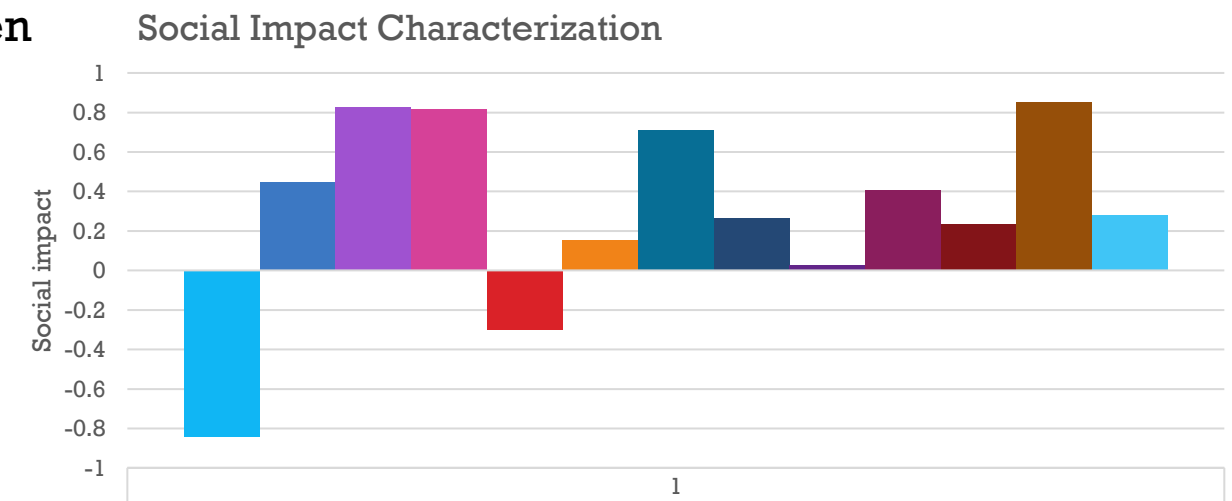
Item	Cost (USD)
Human health (DALY)	60000
Ecotoxicity (species*yr)	1.75E+11
Resource depletion (US$)	1

Heijungs (2008)

Model Results- Social Impacts

Characterization results are between -1 to 1.

1 is the best performance.
-1 is the worst performance.



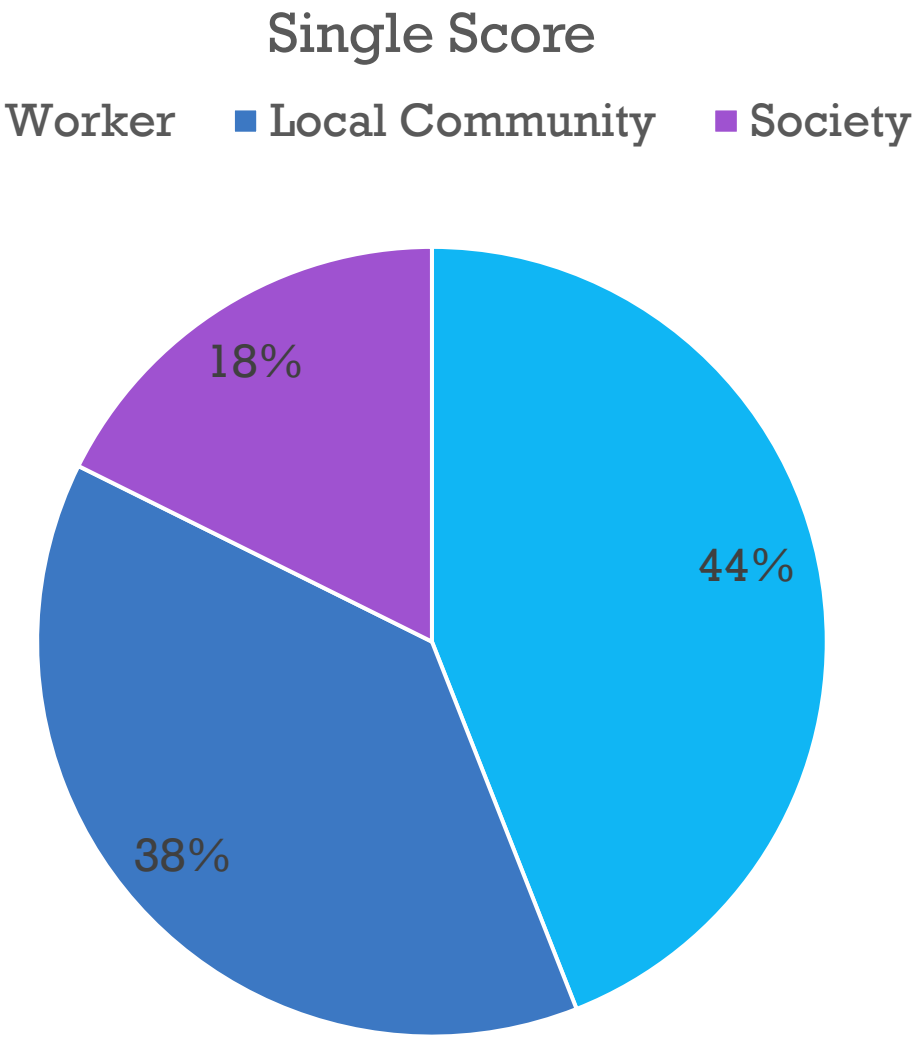
	1
1 Freedom of association and collective bargaining	-0.841280879
2 Child labor	0.445878866
3 Fair salary	0.82858335
4 Working hours	0.81588582
5 Forced labor	-0.303017749
6 Equal opportunities/discrimination	0.155558646
7 Health and safety	0.712213723
8 Access to material resources (e.g. sanitation, school)	0.265081793
9 Cultural heritage	0.025395059
10 Safe / healthy living conditions	0.406861602
11 Community engagement	0.236498444
12 Local employment	0.854448308

Model Results- Social Impacts

Social single score: 1.44

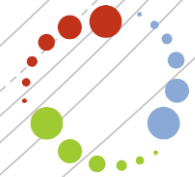
Single score results are from -5 to 5.

5 is the best performance.
-5 is the worst performance.



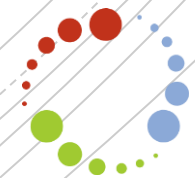
Conclusions

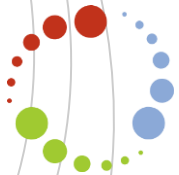
- The studied building has **290 kg CO2 eq/m2**.
- The normalization results show that marine toxicity, human toxicity and freshwater ecotoxicity are most influential impact categories.
- Endpoint results show that Human health and Resources are more impacted by the project than ecosystem.
- External costs are much larger as compared to the construction costs.
- Social single score is 1.44, indicating the social impacts of this project is positive.
- The project has more impacts to Worker and Community than to the Society.



Conclusions

- Future work:
  - To study the downstream stages of the building project, including use, end-of-life.
  - To conduct more case studies of LCSA.



Thank you!

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