What is occurring in tropical large cities in developing countries：

Population increase causes horizontal urban expansion, reducing surrounding greenery and increasing risk of floods.
Mass transportation is poor and traffic jams are caused by rapidly increasing vehicles, especially motor bicycles.
Higher incomes boosts the consumption of electricity. A/C is installed in houses without thermal design.
Houses with shorter service lives consume materials causing destruction of forests and consumption of fossil fuels.
Solutions can be sought through invention and socialization of images of new utopia, before inflation of fossil fuels' price. Tropical traditional houses that have coexisted with nature offer many suggestions for future, through their design and usage of materials.

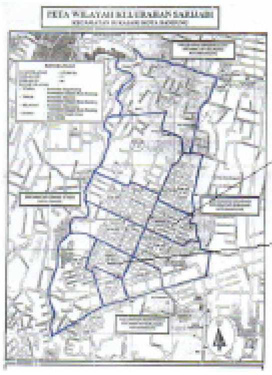
1. Analysis of satellite images to grasp existing conditions

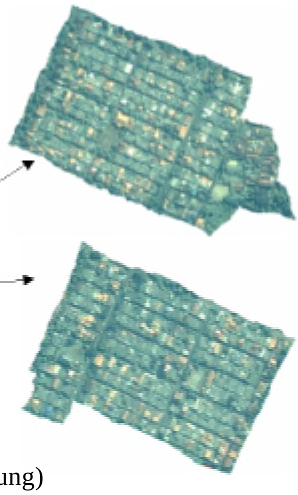
(1) Identification of houses supports field survey activities

Bandung: IKONOS(1m), Cirebon and Malang:Quick Bird (0.6m)

Initial form of houses

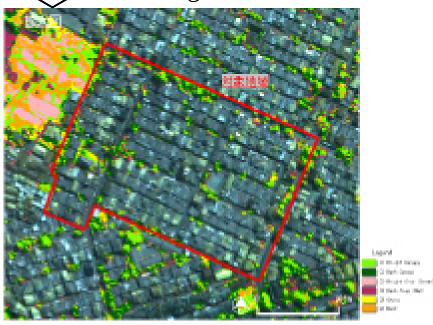
Extended houses





Town planning in 1970s
(Sarijadi complex in Bandung)

Analysis of 4 bands identifies area of canopy of trees, covering 11 % of total area.



(2) 「ALOS」(2.5m): Acquisition of DEM from stereo pair image
→Identification of Low wet coastal zone and slope area.

Table 4 Optimal parameters for matching

Area	Area for searching (pixels)		Size of matching window (pixels)		Lower limit of coefficient
	X	Y	X	Y	
Bandung	31	3	3	3	0.5
Cirebon	11	3	7	7	0.5

More detailed DEM was obtained from satellite images (left) than that from geographical map1:25,000 (right).

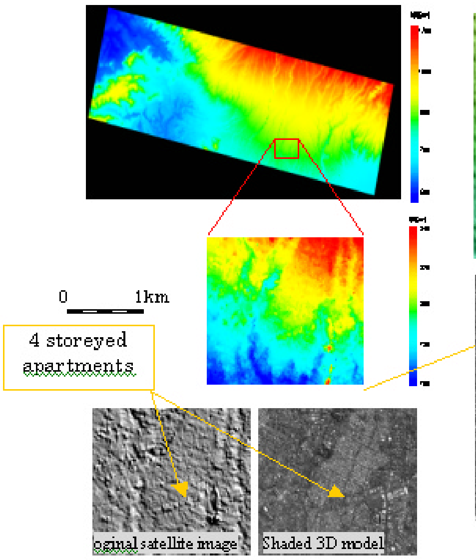


Fig. 2 The obtained DEM data for Bandung

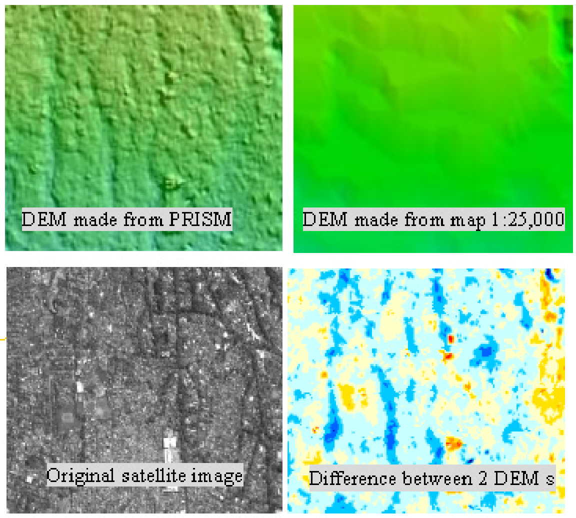
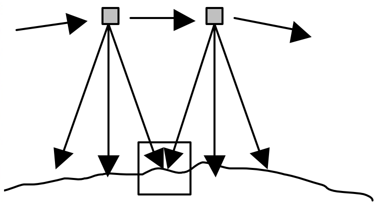


Fig. 3 Comparison of DEM from PRISM & GeographicalMap 1:25,000



Satellite "DAICHI" (ALOS)
Sensor：PRISM
Analysis of stereo pair images taken from different angles provides 7.5m DEM with 1m resolution of altitude, corresponding to the height of roofs, green canopies and vacant land.

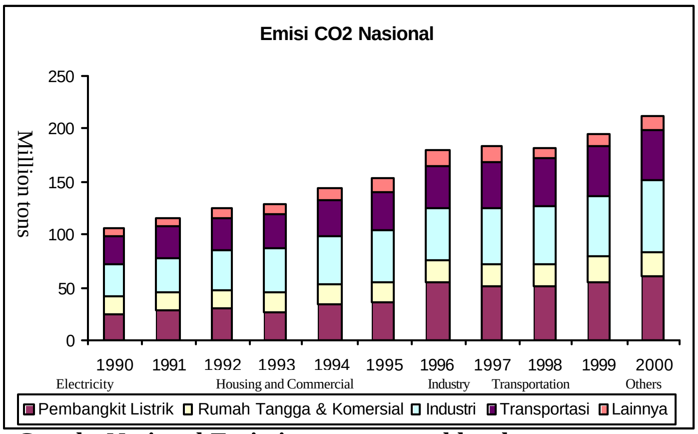
2. Field Survey of Life

Under supervision of the Research Center for Human Settlements Ministry of Public Works, a questionnaire survey was performed of 900 sample households from 13 planned housing complexes in 7 Indonesian Cities. Most were masonry houses made by greatly expanding the original houses. Domestic consumption of energy and of fuels for transportation and usage of building materials were monitored. Building material factories were also surveyed to identify the life cycle emission of each material occurring outside of the complexes. The length of life of houses was c.a. 15 years, to calculate annual emission through building materials compared to that of domestic energy and vehicle fuels.

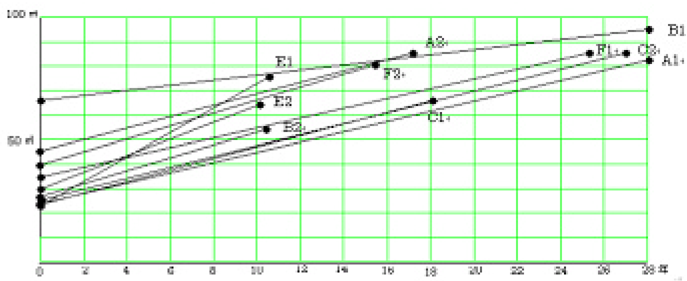
Fig: Cities surveyed

Table: Housing complexes surveyed

A.Bandung city	A1 :Sarijadi Complex (public)
	A2 :Antapani Complex (public)
B.Cirebon city	B1 :Hardjamukti Complex (public)
	B2 :Gulia Sunyaragi Permai Complex (private)
C.Semarang city	C1 :Banyumanik complex (public)
	C2 :Peramongan Indah complex (private)
D.Malang city	D1 :Sawojajar complex (public)
E.Mataram city	E1 :Seweta Indah complex(public)
	E2 :Bakudan Permai(private)
F.Makassar city	F1 :Banakukan complex(public)
	F2 :Bumi Tamalanrea Permai complex(private)
G.Banjarmasin city	G1 :Buruntung complex(public)
	G2 : HKSN complex(private)



Graph: National Emission, announced by the government



Graph: Average floor area of houses, original and current
(Big increase, however still under 100m²)

- In spite of a monetary crisis(1997), constantly increasing, doubling every 10 years
- Contribution of electricity is large. It is highly dependent on income according to the survey finding.
- In this research, evaluation is not confined to "housing" sector, but also include the indirect emissions that are classified in other sectors in this graph.

Table: Emission coefficient used

- Electricity:0.684KgCO_2／kWh
  (Diesel generators are popular in local cities.)
- Kerosene 1 liter emits 2.54kg-CO_2
  Weight0.8136Kg/L Carbon weight 85%
- City gas 1m3 emits 2.031kg-CO_2
  Weight0.677Kg/m3 Carbon weight 81.8%
- LPG 1Kg emits 2.999kg-CO_2
  Carbon weight0.818kg/L

Table: Total annual emission of household (kg–CO_2/Year/Household)

cities	Samples	Domestic	Transportation	B. material	Total
Bandung	200	2,390	1,455	108	3,868
Cirebon	200	1,891	751	76	2,708
Makassar	100	2.262	821	75	3,159
Banjarmasin	100	2,120	1,322	81	3,502
Semarang	100	1.976	1,092	72	3,199
Mataram	100	1,870	1,223	99	3,192
Malang	100	2,087	1,179	85	3,350

One average household emits 3-4 tons of CO_2 in one year.

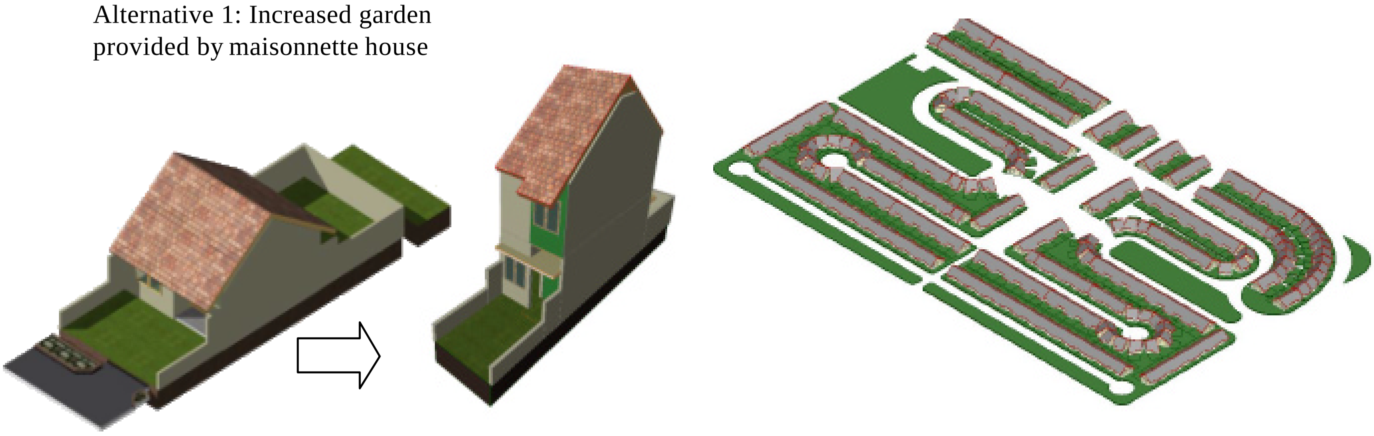
National total emission is 200 million tons per year, therefore one ton per person per year, and the survey result is comparative to this. The survey targets are urban planned housing areas, and the average emission per year is probably relatively larger than national average of whole houses including rural settlements.

3. Planning alternative futures

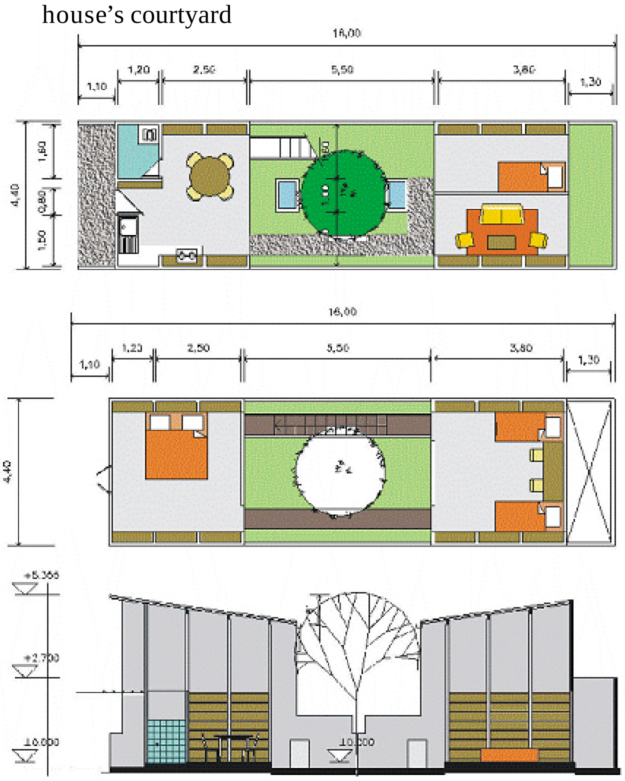
With the participation of Indonesian architects and city planners, alternative plans were elaborated for two actual districts in Bandung and Cirebon cities, considering the “emission”, instead of usual “cost”. Before starting the design, a workshop was held in Bandung (March 2006) in order to discuss the basic concepts, including the understanding of system boundary, saving energy and electricity, LCE (life cycle emission) of building materials and carbon stock effect, evaluation of greenery (absorption of CO_2 and exterior heat), natural ventilation, and transportation trip of vehicles. Several new solar cells, building greenery, high-rise building and low house combination, etc. were proposed.

Elaborated alternative plans were presented in the form of three dimensional data, with explanations of concepts and reduction of CO_2 emission, at the workshop, held with invited non-engineer resource persons and citizens in the target areas (March 2007).

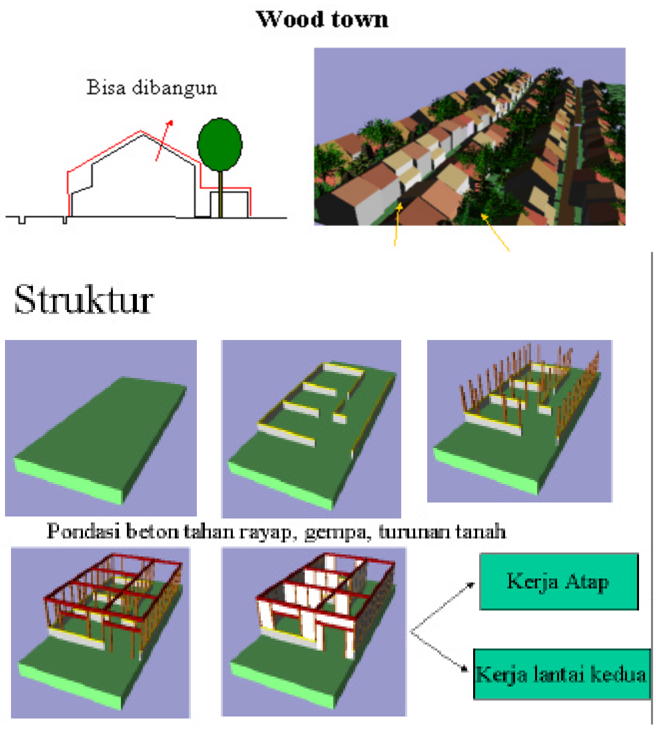
Alternative 1: Increased garden provided by maisonnette house



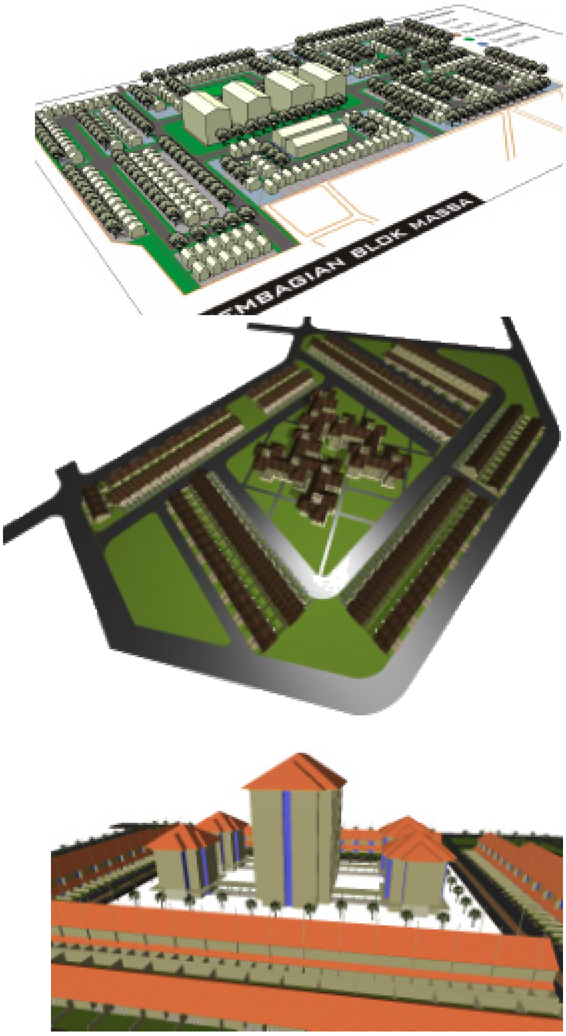
Alternative 2: Planting a tree in every house’s courtyard



Alternative 3: Carbon stock in fire-proof timber houses



Alternative 4,5,6:Creation of greenery by apartment



Alternative 7: Greenery on roofs and walls of apartment

Alternative 8: Artificial land, with greenery on top

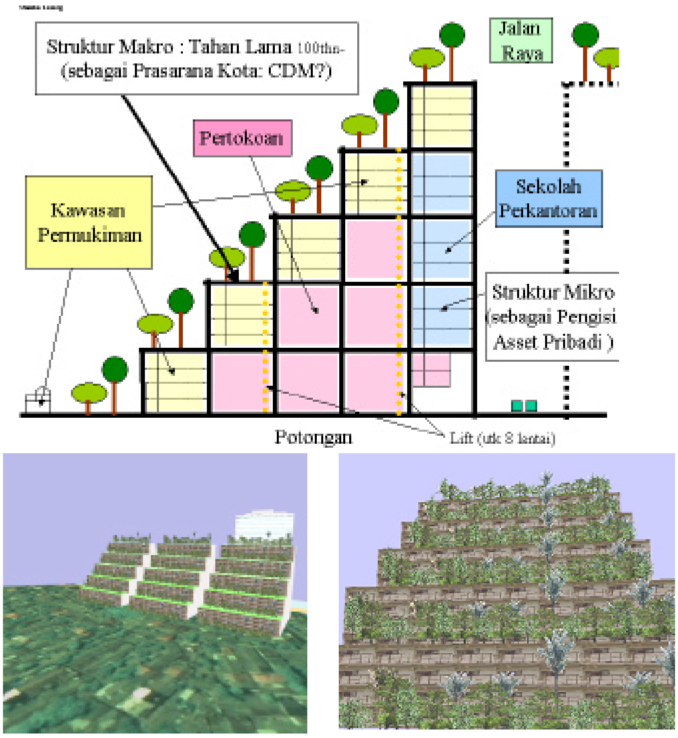


Table: Summary & evaluation of alternatives (Cirebon)

Items	Existing	Plan 1	Plan 2	Plan 3	Plan 4	Unit
Land area	54,700[1)]	54,700	54,700	54,700	54,700	m^2
Total units	324	364	924	578	344	Units
Population	1,090	1,457	3,737	2,312	1,376	Persons
Total floor area	39,056	40,616	136,836	35,616	25,420	m^2
Housing	28,836	32,396	72,036	27,396	17,200	m^2
Non-housing	8,220	8,220	64,800	8,220	8,220	m^2
CO_2 emission/Year/Unit	2.710	5.419	2.382	4.168	4.226	T-CO_2
Building Material LCE	369	15,809	13,483.6	13,369	8,394	T-CO_2
B. material LCE/unit	1.140	43.4	14.6	23.1	24.4	T-CO_2
Expected length of life	15	15	60	15	15	Years
B.Material LCE/Year	24.624	1,054	224.8	891	560	T-CO_2
LCE/Unit/Year	0.076	2.8	0.243	1.54	1.63	T-CO_2
LCE/m^2 of floor/Year	0.00085	0.033	0.0031	0.033	0.033	T-CO_2
Domestic energy/Year/Unit	1.891	1.891	1.891	1.891	1.891	T-CO_2
Transportation/Year/Unit	0.751	0.751	0.263 [n.2)]	0.751	0.751	T-CO_2
Tree cap coverage	4,814	15,614	25,130	14,944	29,994	m^2
Absorption/year [n.1)]	-5.1	-16.6	-26.6	-15.8	-31.8	T-CO_2
Absorption/Year/Unit	-0.008	-0.023	-0.015	-0.014	-0.046	T-CO_2
Carbon Stock in Building	324	364	0	0	0	Ton-C

Absorption of CO_2 by trees is calculated using IPCC default value of 2.9 ton-C/Year), however this must be larger in tropical zones, and it is now studied through forestry researches.
Carbon stock is related to the amount of timber as a building material.

Photo: discussion and evaluation workshop (2007.3.6-7)

The evaluation of a housing complex still does not reflect its location of in an overall city, therefore the whole city is not evaluated. In the next step, evaluation of the total city must be done by comparing new town development in the fringe of city vs. urban renewal in the inner city area.