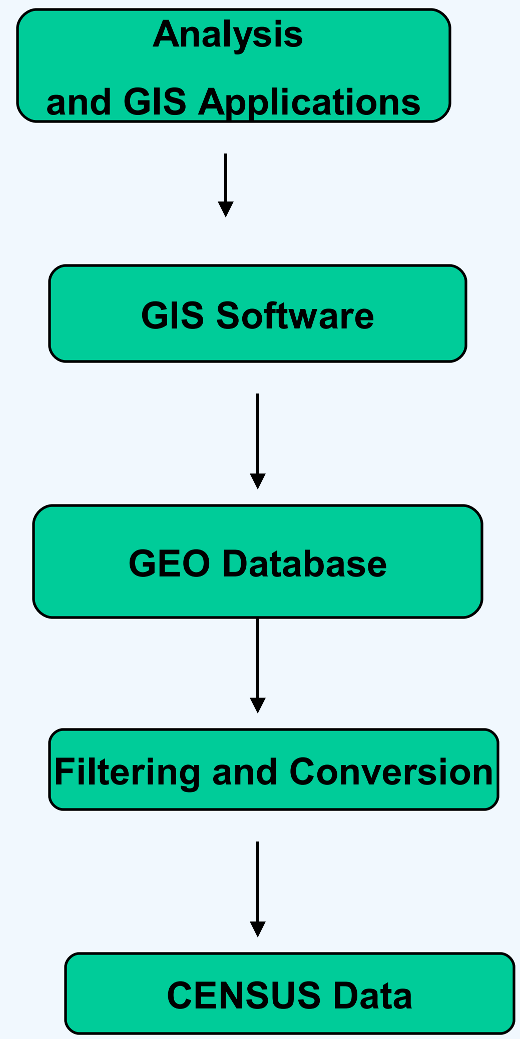
Indian Situation

- Population – More than 1 Billion
- Data at - State Level
  - Regional Level
  - Household Level
  - Individual Level



Evaluating Open Source GIS software for environmental planning in developing countries

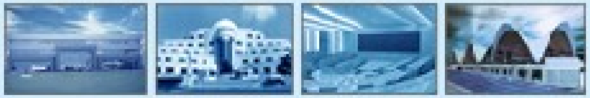
Amit Jain
amit_jain08@infosys.com

Infosys Technologies, India

Map Middle East
9-11 April, Dubai

Infosys Technologies (www.infosys.com)

- CMM level 5
- 70,000 Employees
- More 25 development centers around the world including UAE
- Turnover more than 3 b$
- Working in the domain of GIS, Banking, Retail, Health sector, transport
- First Indian company to be listed in NASDAQ



Presentation Outline

- Introduction
- Analysis Of Different GIS Waste Management Models
- A Specific Integrated GIS Waste Assessment Model
- Basic Equations Governing The Software Model
- Application Of Model
- Economic viability of treatment technologies for Indian cities
- Landfill Sites Selection and Location
- Convergence with GIS
- Concept Of GIS Based Decision Support System.
- Conclusion

NALYSIS OF DIFFERENT WASTE MANAGEMENT MODELS

hang *et.al*. (1997) → **'Time Series Intervention Model**

wai *et.al.* (1980) → **Multi-sector Equilibrium Model**

ang *et.al.* (1995) → **mixed-integer linear model**

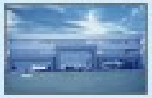
iamadopoulous *et.al*. (1994) → **Integer Linear Programming Model**

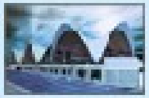
HOW IT IS DIFFERENT FROM DEVELOPED COUNTRIES:

- ✓ A high organic content
- ✓ Poor performance of the formal sector
- ✓ Extensive informal activities
- ✓ Low per capita levels, high aggregate levels
- ✓ Cost of GIS models and Products

Research Problem

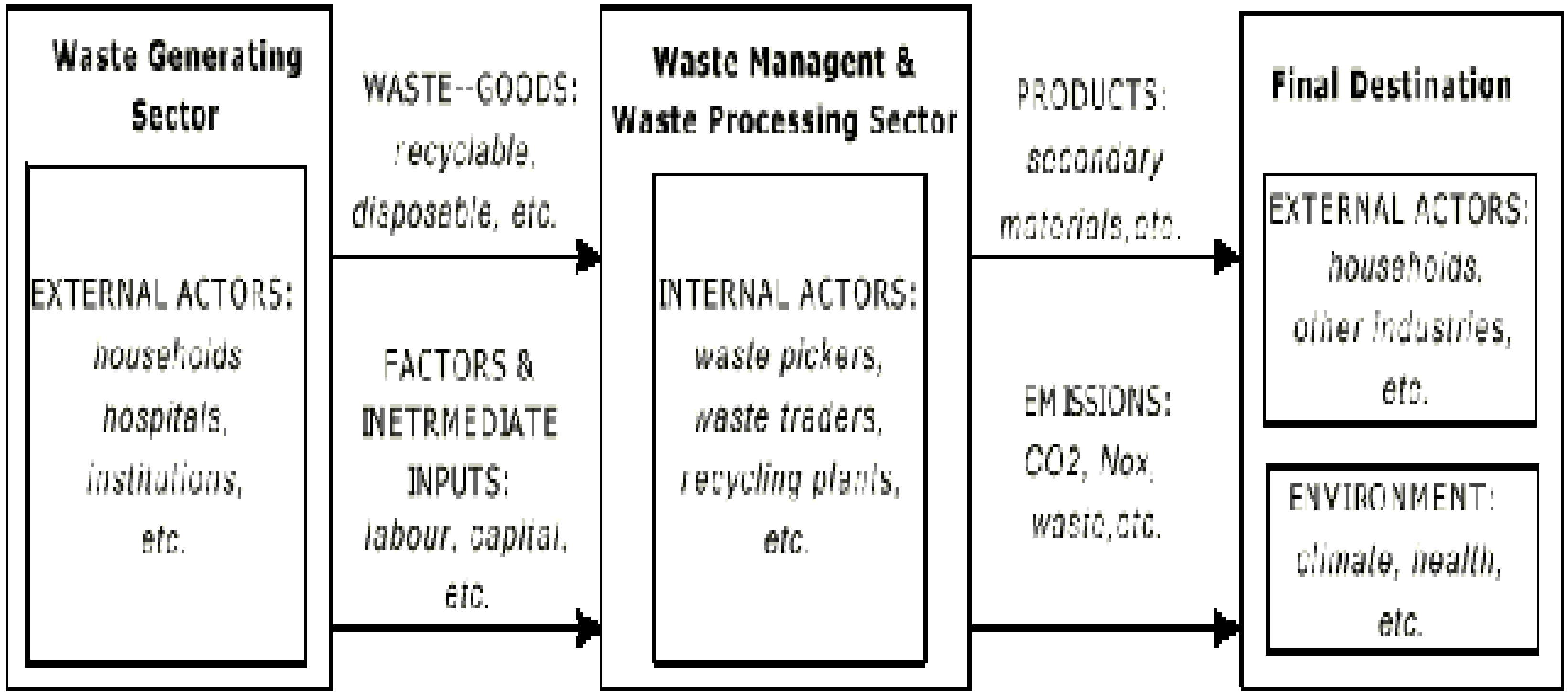
- Landfill site selection and location
- Analysis of existing GIS models
- Open Source Software
  - Does not take typical developing countries perspective
  - Not as advanced as commercial software
  - Free of Cost
  - Source Code available, can be customized



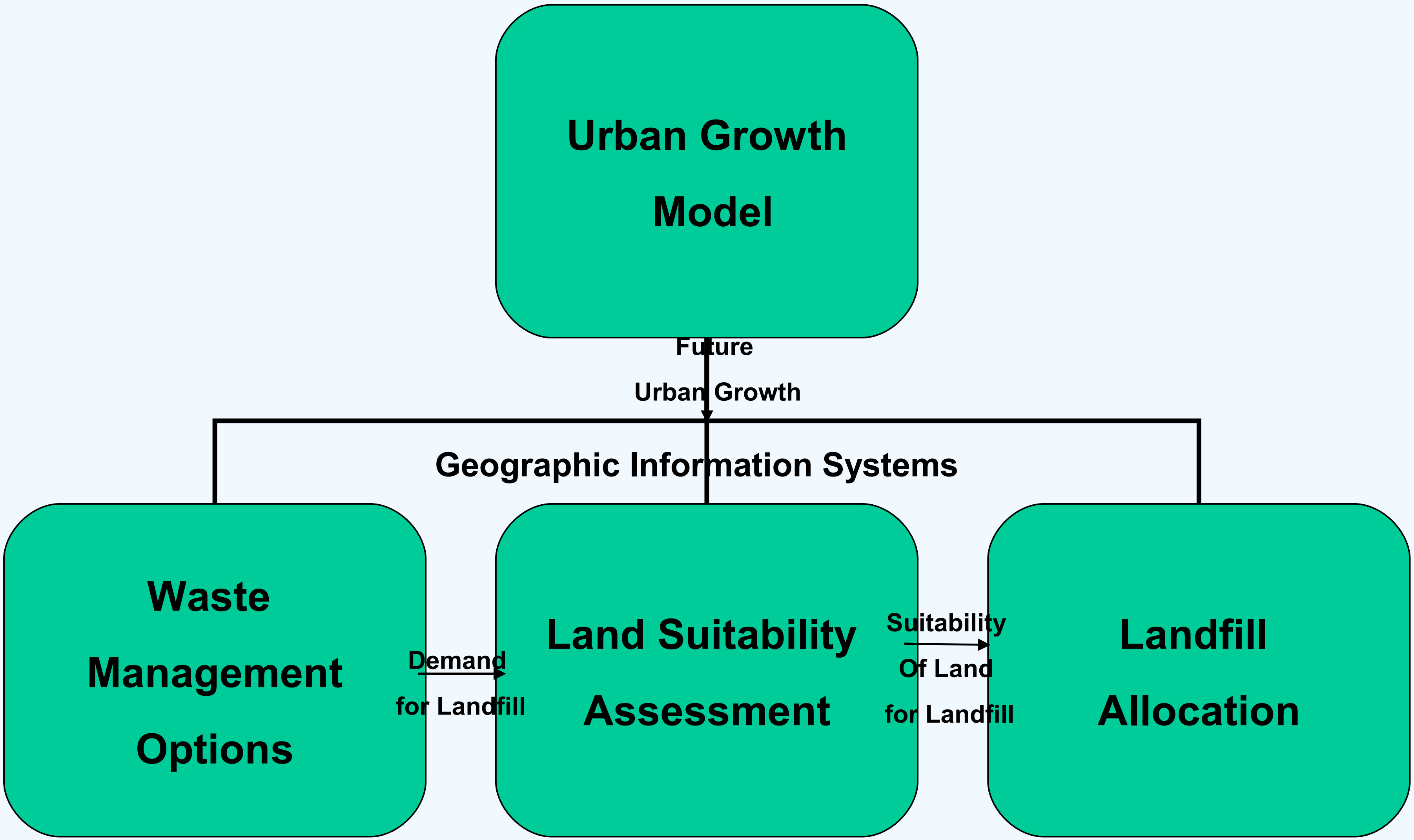



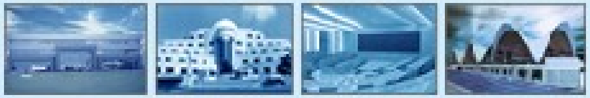
LOCATION SELECTION

A SPECIFIC INTEGRATED WASTE ASSESSMENT MODEL

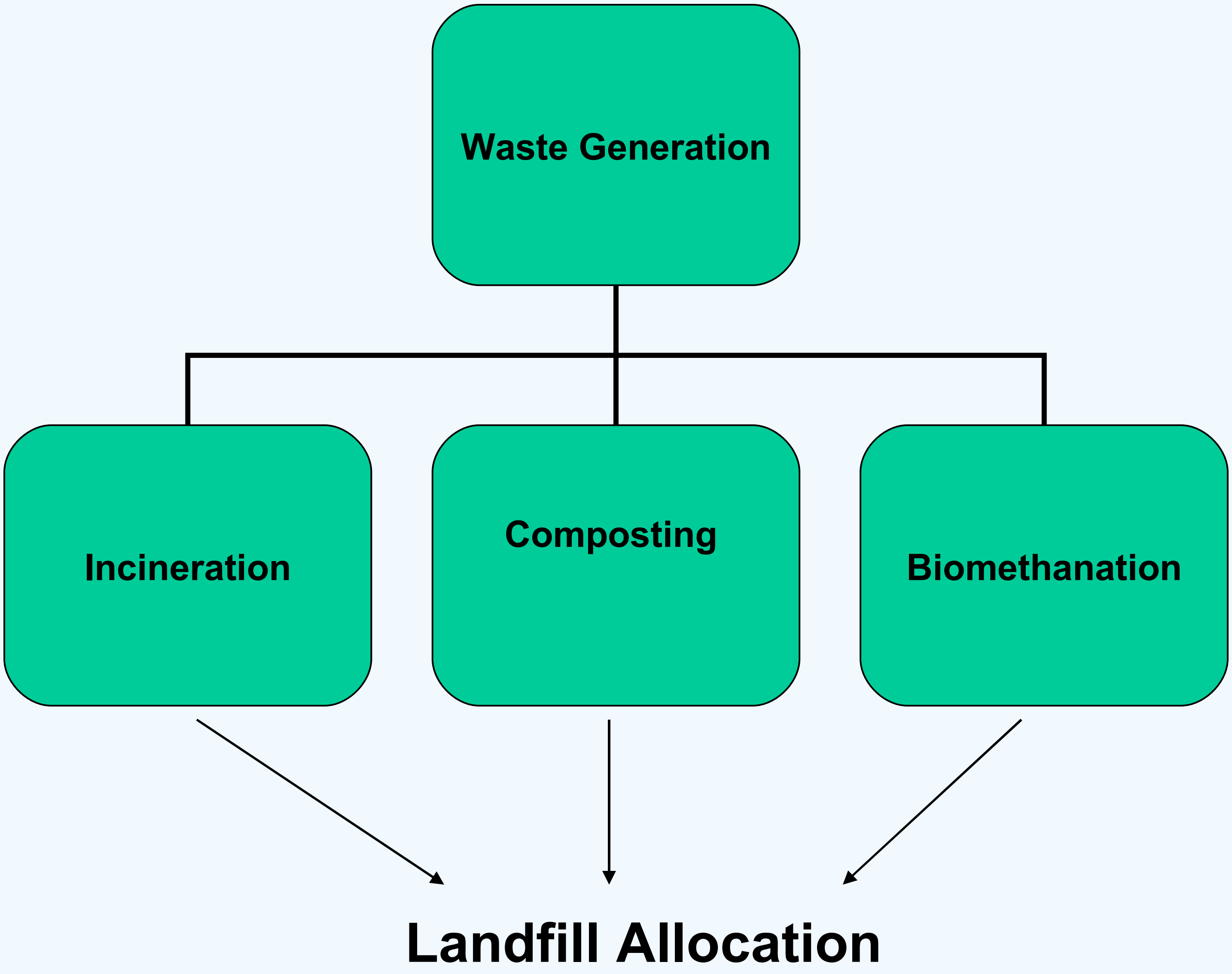


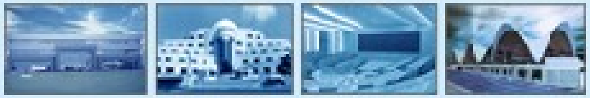
Dynamic model for Landfill demand and allocation





Integrated Solid waste Disposal System





Following Equation Was the Basis of the Above Model:

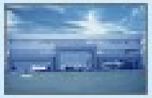
min cost involved = Input cost – Output cost

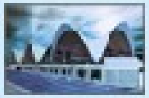
$$\min c = \sum_{k \in K} p^k \tilde{r}^k - \sum_{h \in H} \sum_{j \in J} \tilde{p}^{j',h} \tilde{y}^{j',h}$$

min c = Input – Output

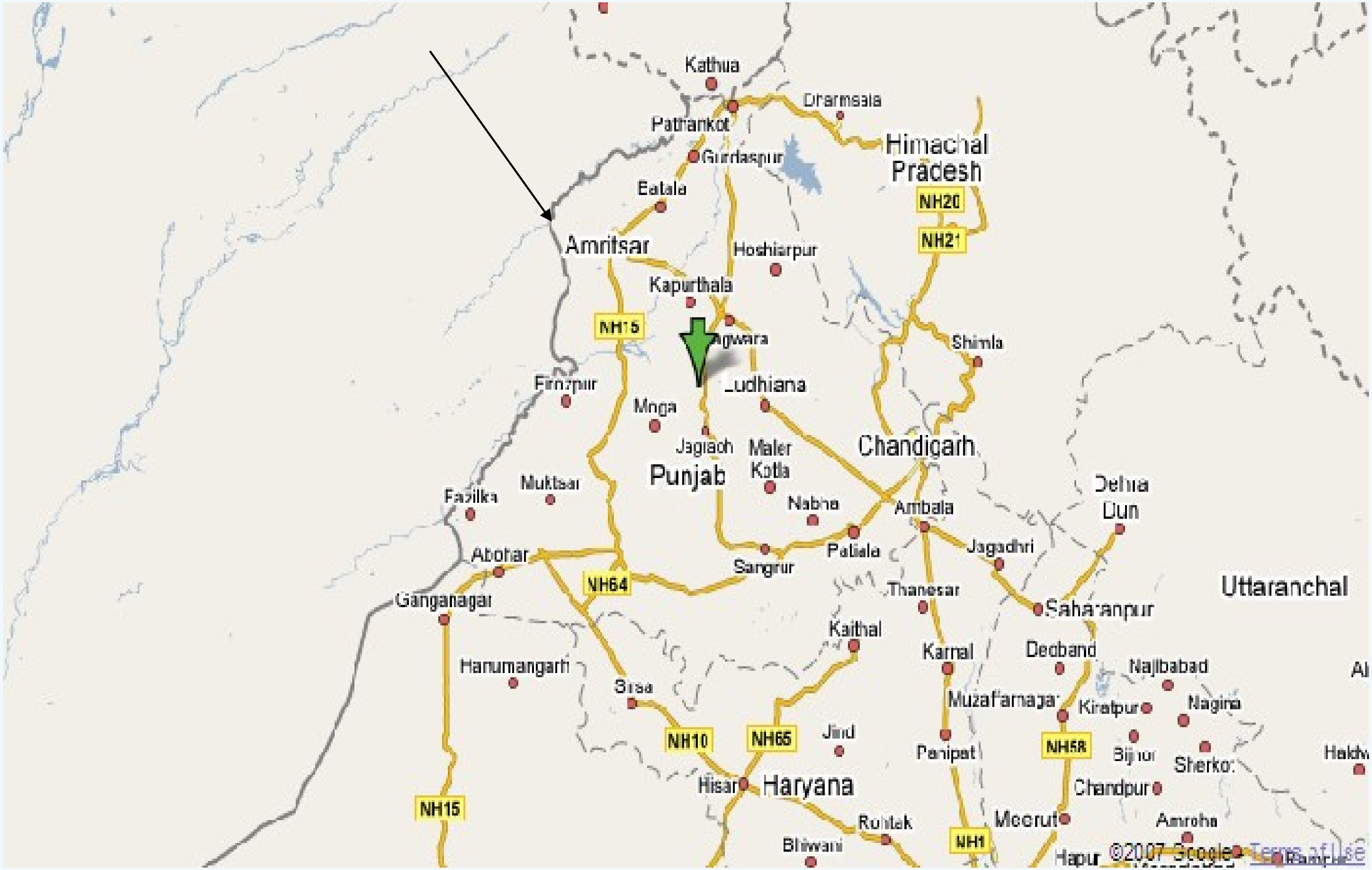
Input = variable cost +interest on capital cost + cost of marketing

Output = recovery by sale of electricity or organic manure or both.



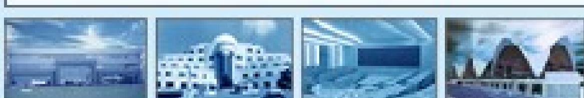



Municipal Corporation Amritsar

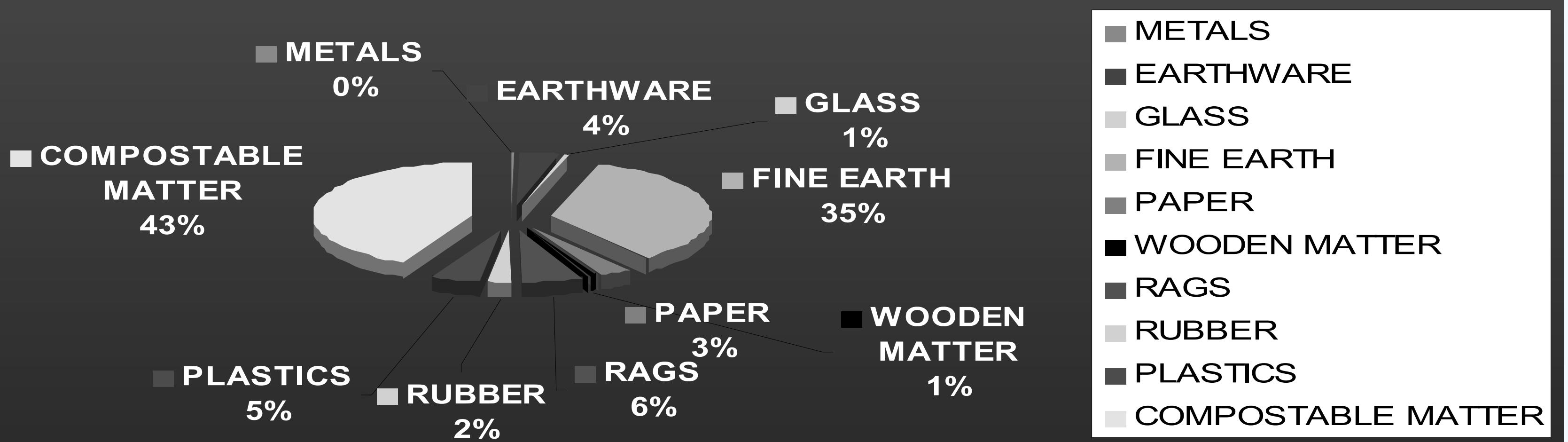


Detailed physical analysis of MSW of Amritsar

	RESIDENCIAL AREA	INDUSTRIAL AREA	MIXED AREA	AVERAGE
CALORIFIC VALUE(kcal/kg)	1898	1251	1398	1548
VOLATILE MATTER (%)	38	19	27	29
MOISTURE CONTENT (%)	54	26	53	47
COMPOSTABLE MATTER (%)	40	47	40	42
DENSITY (kg/cum)	450	485	425	440
Quantity of MSW (tons/day)	329	77	82	488



AVERAGE



Source : Municipal corporation of Amritsar

FUNDAMENTAL MATHEMATICAL EQUATIONS INVOLVED IN THE COMPUTER MODEL

Recovery by heat recovery (incineration technology)

Total waste quantity : W tons

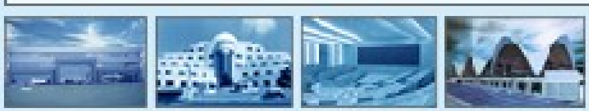
Net Calorific Value : NCV kcal/kg.

Energy recovery potential (kWh) = NCV x W x 1000/860

= 1.16 x NCV x W

Power generation potential (kW) = 1.16 x NCV x W/ 24

= 0.048 x NCV x W



Typical *Waste-to-Wire* Conversion Efficiency = 25%

Net power generation potential (kW) = 0.012 x NCV x W

If NCV = 1200 kcal/kg., then

Net power generation potential (kW) = 14.4 x W

Output = 14.4 X W X cost of power per unit

Recovery by gas production (biomethanation)

Total waste quantity : W (tonnes)

Total Organic / Volatile Solids : VS = 50%, say

Organic bio-degradable fraction : approx. 66% of VS

= 0.33 x W

Typical digestion efficiency = 60%

Typical bio-gas yield: B (m3) = 0.80 m3/kg. of VS
estroyed

= 0.80 x 0.60 x 0.33 x W x1000 = 158.4 x W

Calorific Value of bio-gas = 5000 kcal/m3 (typical)

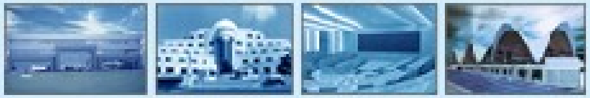
Energy recovery potential (kWh) = B x 5000/860 =921 x W

Power generation potential (kW) = 921 x W/ 24 = 38.4 x W

Typical Conversion Efficiency= 30%

Net power generation potential (kW) = 11.5 x W

Output = 11.5 X W X cost of power per unit



Recovery by sale of organic manure (composting)

Total waste quantity : W (tonnes)

Moisture content : 50%

Dry mass = 0.5 X W

Compostable matter = 50%,

Production of organic manure = 0.5 X 0.5 X W

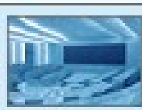
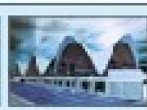
Out put = 0.25 X W X cost of manure per unit mass

APPLICATION OF MODEL

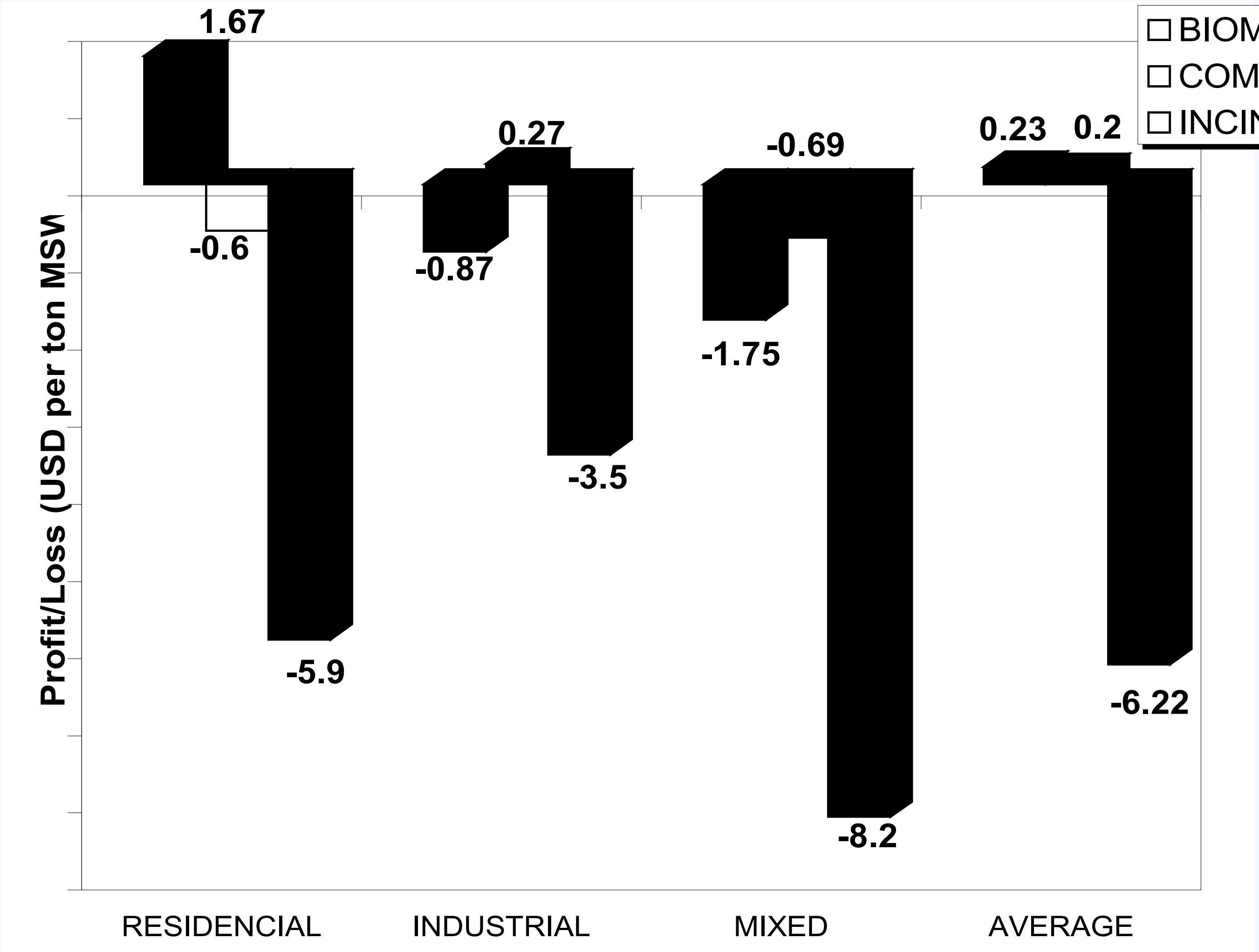
Economic viability of treatment technologies for average MSW characteristics

	Biomethanation	Incineration	Composting	Landfilling
(A) General features				
Capital cost (Million USD)	8.2	6.67	1.1	0.16
Operating cost (USD per ton)	7.3	9.6	3.8	1.24
(B)Annual expenditure (Million USD)				
Operating cost	1.330	1.45	0.57	0.189
Interest on capital cost @ 0.75% per annum (soft loan)	0.065	0.05	0.008	0.001
Cost of marketing @ USD 1.1 per ton of organic compost	0.020	-	0.04	-
Sub-total	1.415	1.5	0.62	0.19
(C) Annual recovery (Million USD)				
Sale of power @ USD 0.05 / KWH	1.150	0.5	-	-
Sale of organic compost @ USD 18 per ton	0.300	-	0.65	-
Sub. Total	1.450	0.5	0.65	0.213
(D) Yearly profit/loss margin (Million USD)	0.035	-1.0	0.03	0.02
(E) Profit/Loss margin (USD per Ton of MSW)	0.23	-6.62	0.20	0.13



Comparison of different treatment options for different zones of Amritsar



[Journal Home Page] [Search the Journals] [Table of Contents] [PDF version of this article] [Download to Citation Manager] [Purchase Article]

Environ. Sci. Technol., 39 (10), 3732 -3735, 2005. 10.1021/es0492236 S0013-936X(04)09223-5
Web Release Date: April 15, 2005

Computer Model for Municipal Solid Waste Treatment in Developing Countries

Amit Jain,† Harsangeet Kaur, and Sunil Khanna*

Department of Biotechnology and Environmental Sciences, Thapar Institute of Engineering and Technology, Patiala 147004, India

Received for review May 26, 2004

Revised manuscript received March 14, 2005

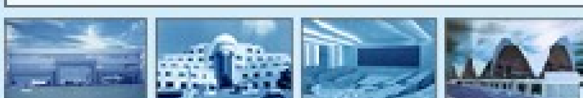
Accepted March 15, 2005

Abstract:

Many integrated solid waste management (ISWM) models are available but are of little use to developing countries such as India since they do not take into accoun typical developing countries municipal solid waste characteristics such as high organic content, poor performance of formal sector control and support, high activity of scavengers and waste pickers, etc. The goal of this study is to create a computer program to determine the least cost treatment and disposal system for a given solid waste management problem. To demonstrate its applicability, the model was applied to the Indian city Amritsar. A typical Indian city like Amritsar generates about 500 ton of MSW/d with 15% moisture content, 30% volatile matter, and calorific value of 1500 kcal/kg. The computer model was run for various

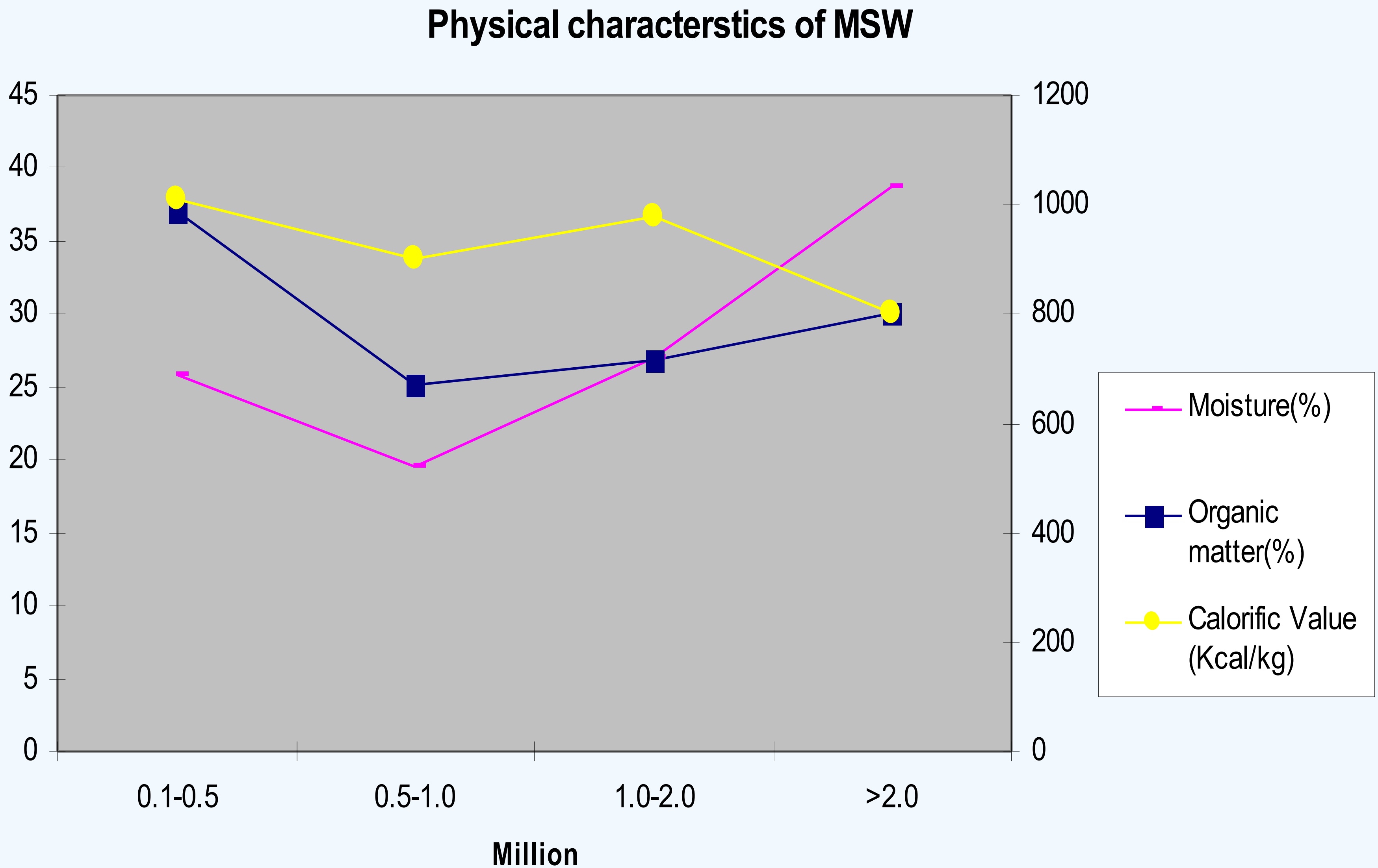
Physical characterstics of MSW

Population range (Million)	Paper (%)	Rubber/Leather(%)	Glass (%)	Metals (%)	Compostable(%)	Inert (%)
0.1-0.5	2.91	0.78	0.56	0.33	44.57	43.59
0.5-1.0	2.95	0.73	0.35	0.32	40.4	48.38
1.0-2.0	4.71	0.71	0.46	0.49	38.95	44.73
>2.0	6.43	0.28	0.94	0.8	30.84	53.9

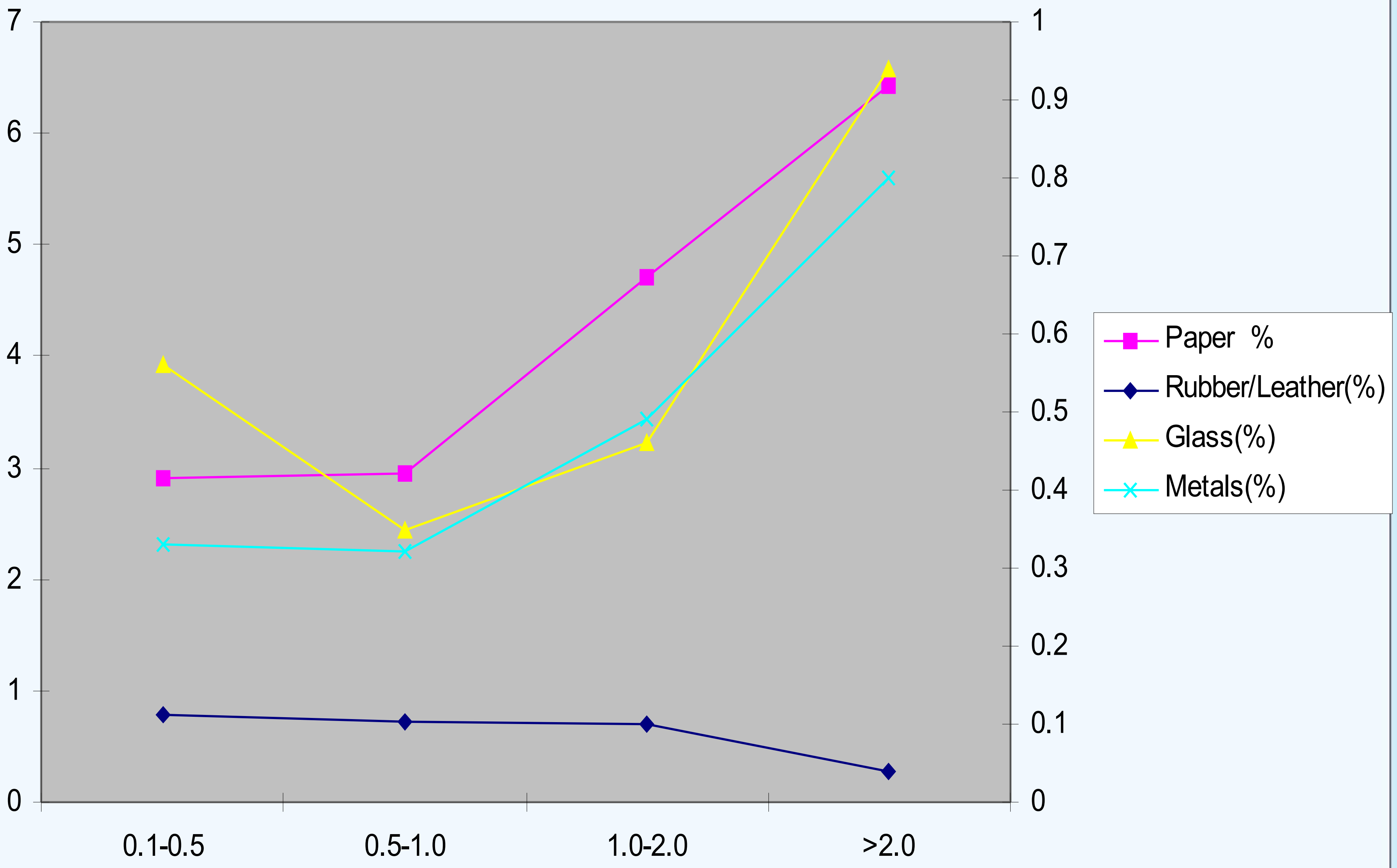


Chemical characterstics of MSW in Indian cities

Population range (Million)	Moisture(%)	Organic matter(%)	Calorific Value (Kcal/kg)	C/N Ratio
0.1-0.5	25.81	37.09	1009	30.94
0.5-1.0	19.52	25.14	900	21.13
1.0-2.0	26.98	26.89	980	23.69
>2.0	38.72	30.07	800	30.11

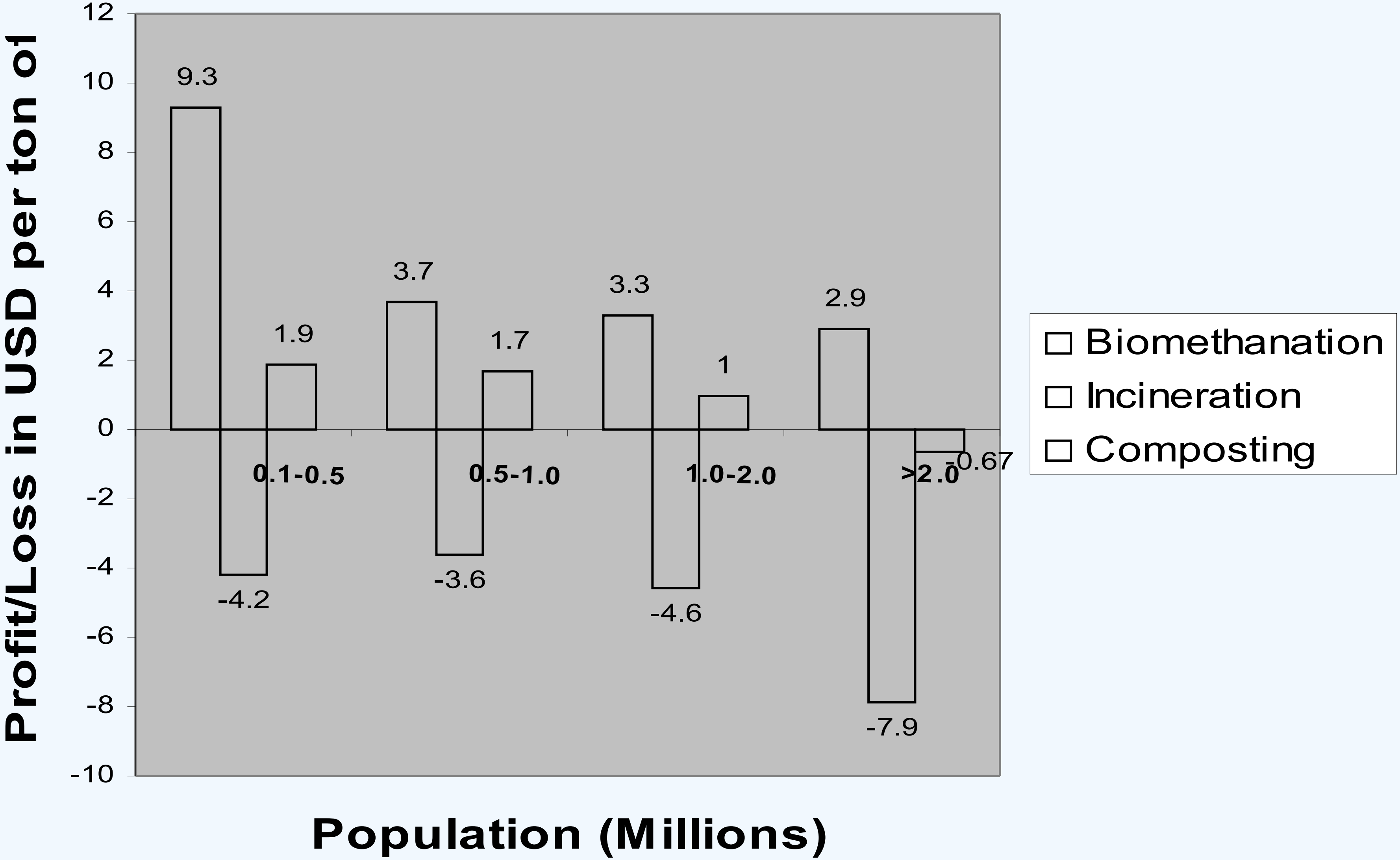


Physical characterstics of MSW
45
40
35
30
25
20
15
10
5
0
1200
1000
800
600
400
200
0
0.1-0.5
0.5-1.0
1.0-2.0
>2.0
Million
Moisture(%)
Organic matter(%)
Calorific Value (Kcal/kg)

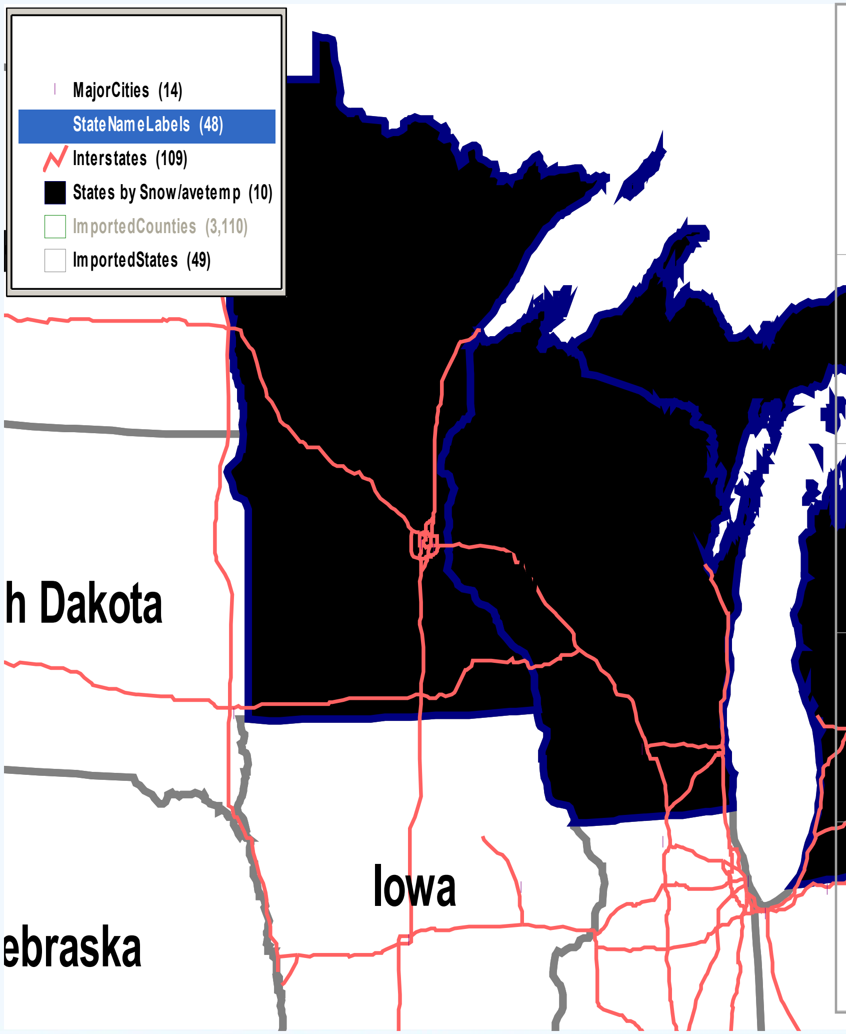


7
6
5
4
3
2
1
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.1-0.5
0.5-1.0
1.0-2.0
>2.0
Paper %
Rubber/Leather(%)
Glass(%)
Metals(%)

Economic viability of treatment technologies for average MSW characteristics of Indian cities



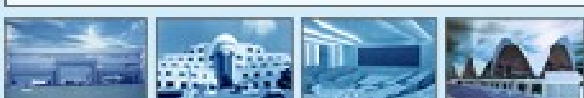
LOCATION SELECTION



Population range (Million)	Moisture (%)	Organic matter(%)	Calorific Value (Kcal/kg)	C/N Ratio
0.1-0.5	25.81	37.09	1009	30.94
0.5-1.0	19.52	25.14	900	21.13
1.0-2.0	26.98	26.89	980	23.69
>2.0	38.72	30.07	800	30.11

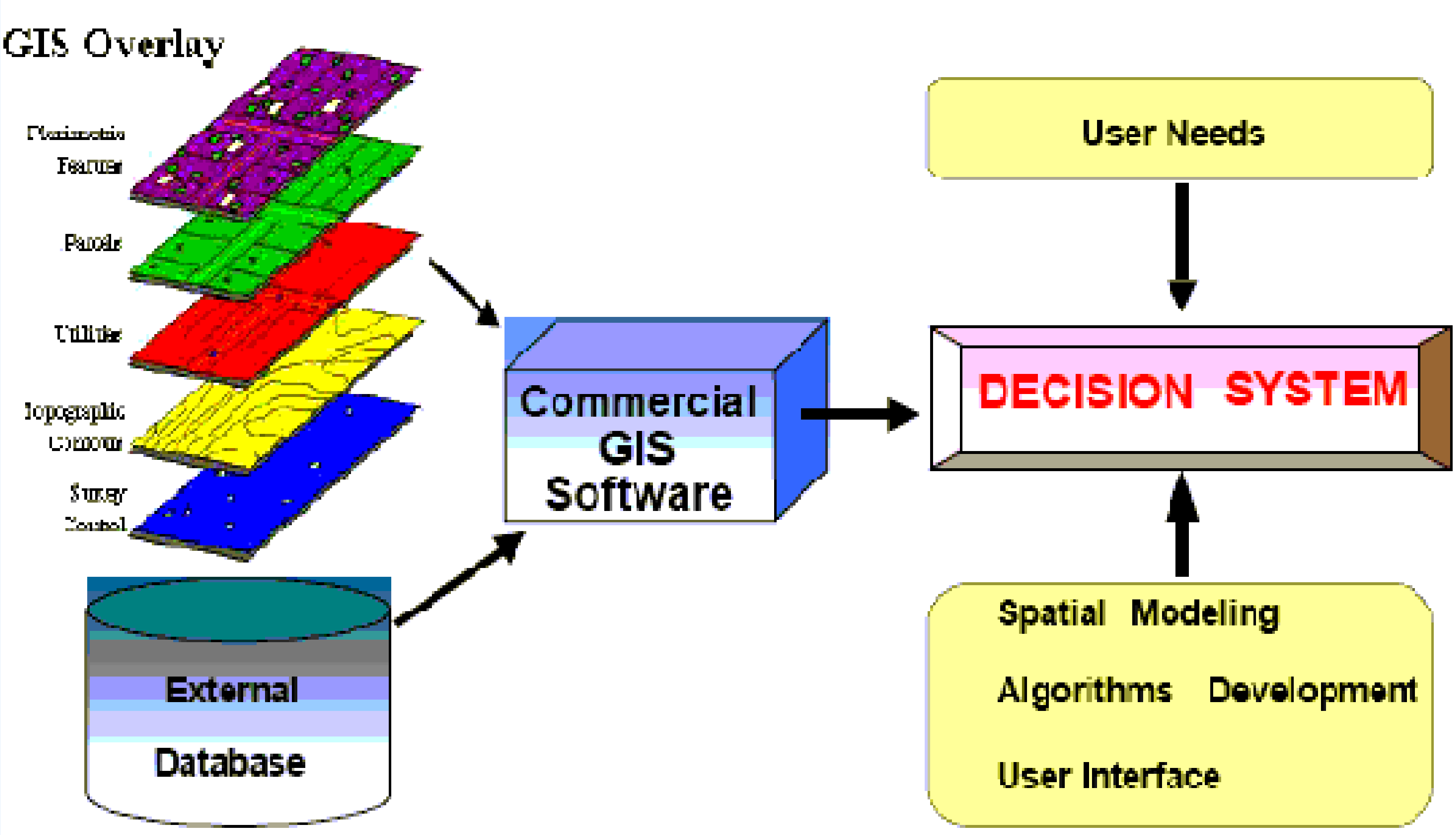
Convergence with GIS

- Township Planning
- Vehicle Tracking Systems
- Environmental Planning
- Security Systems
- Socio-Economic Analysis



GEO - ANALYSIS

Concept of GIS based decision support system.



Thank You