PERU
Cost of Environmental Damage

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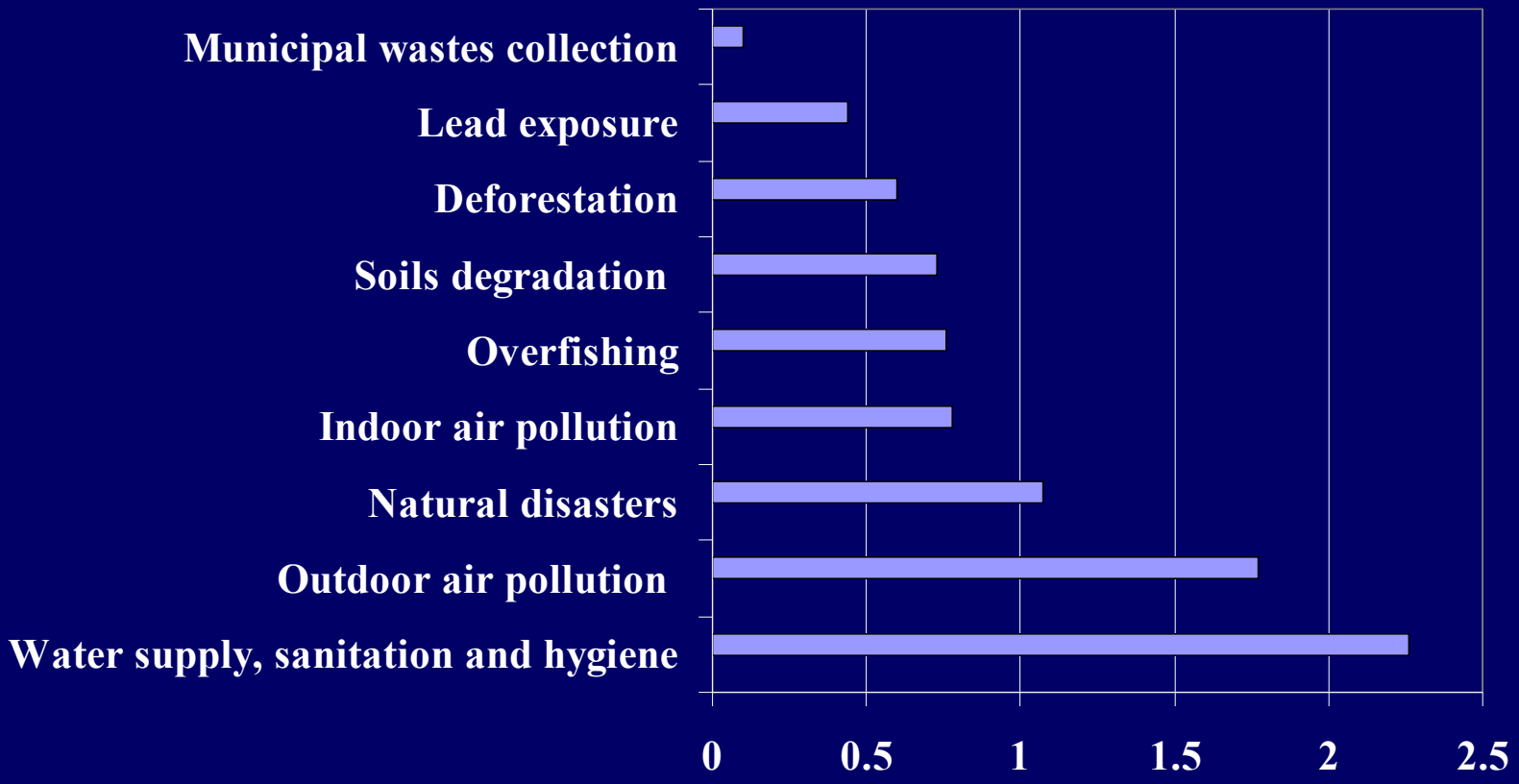
Why Quantification and Valuation?

- Common language
- Ranking of environmental priorities (national and regional/local level)
- Improve efficiency (resource allocation for environmental protection and improvement)

Cost of Environmental Damage

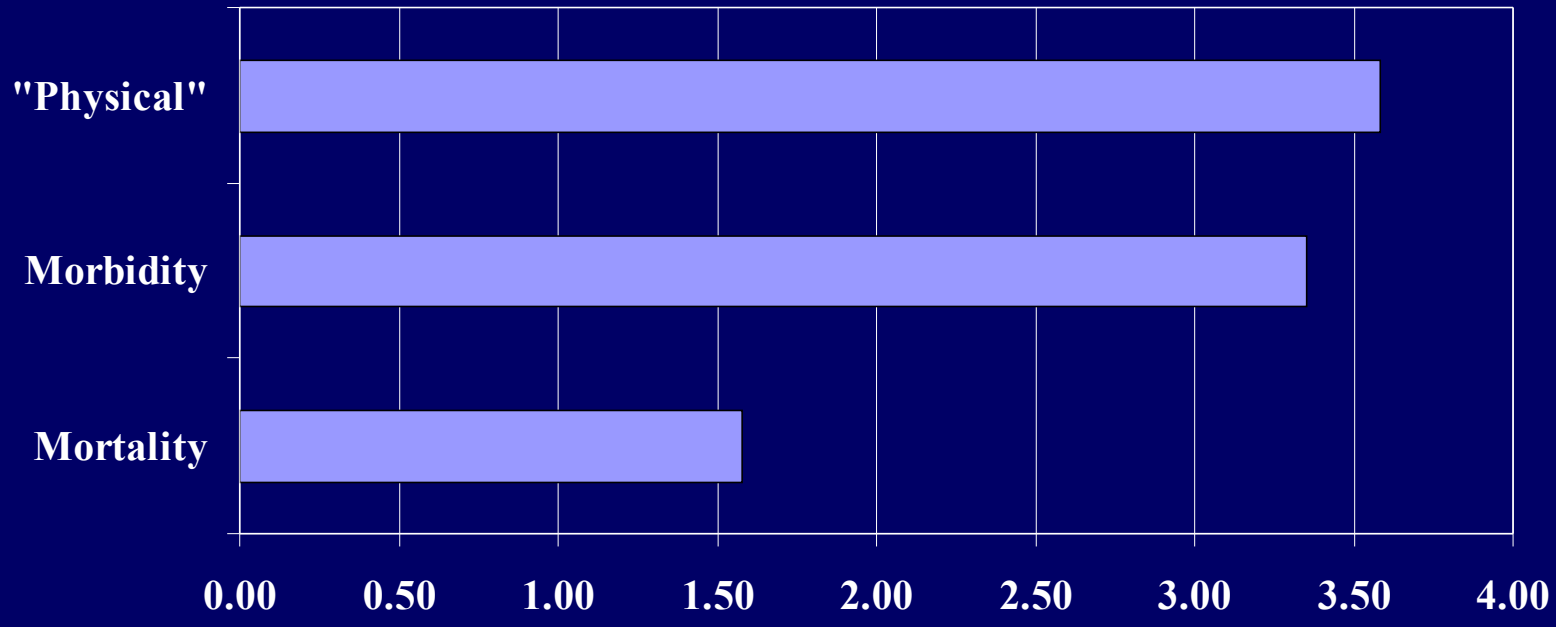
(Billion Soles per Year)



Summary of Damage Cost Estimates

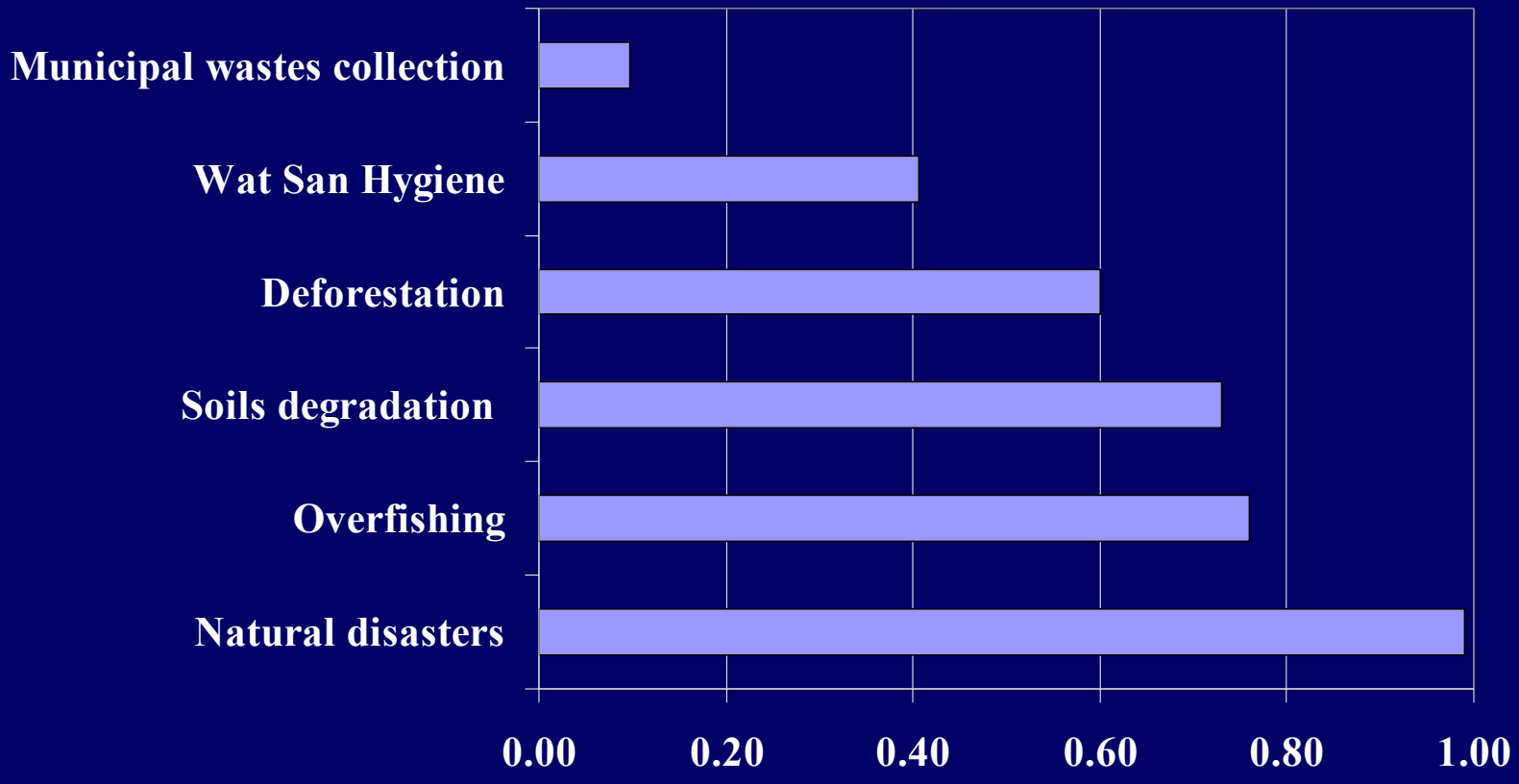
	% of GDP
Water supply, sanitation and hygiene	1.08%
Outdoor air pollution	0.84%
Indoor air pollution	0.37%
Lead exposure	0.21%
Municipal wastes collection	0.05%
Sub total	2.5%
Overfishing	0.36%
Soils degradation	0.35%
Deforestation	0.26%
Natural disasters	0.51%
Sub total	1.5%
TOTAL	4.0%

Cost By Type of Damage
(Billion Soles per Year)

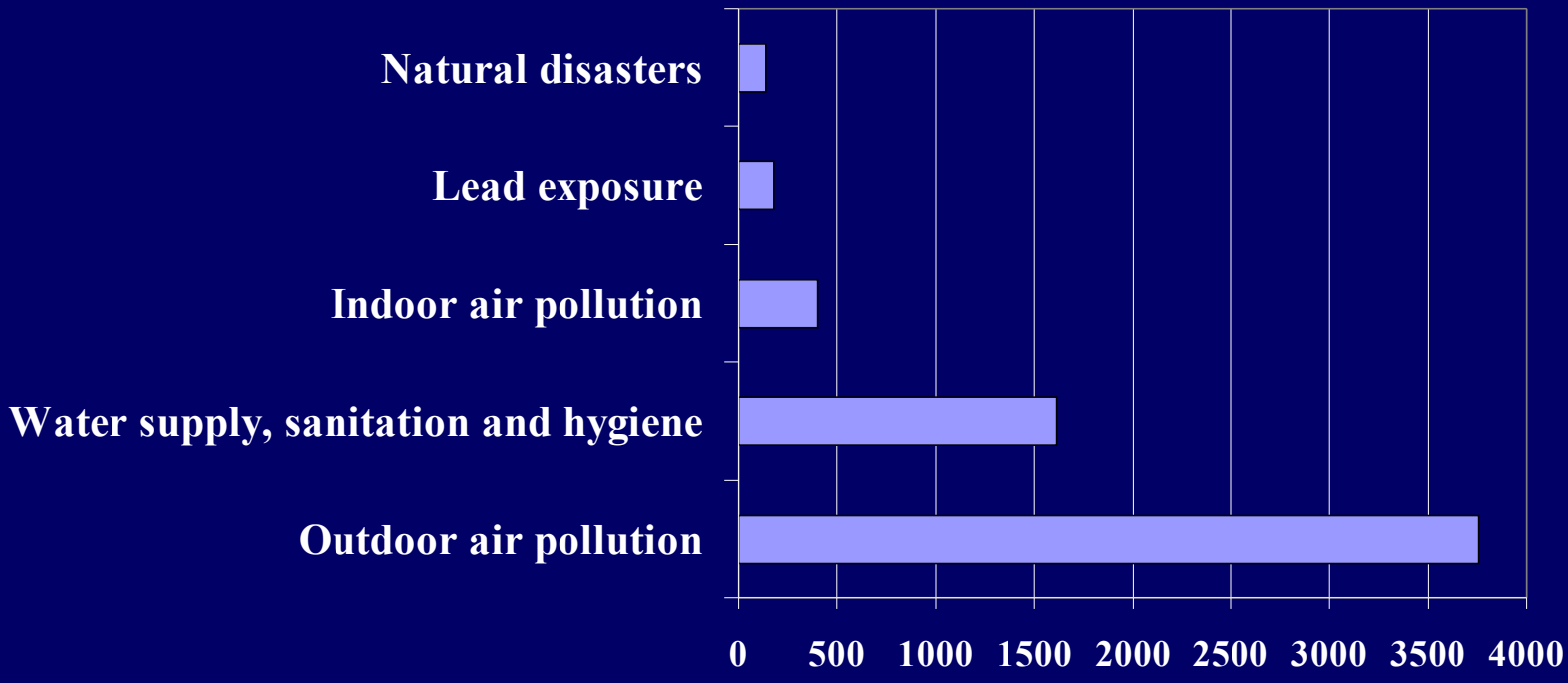


“Physical” Cost By Category

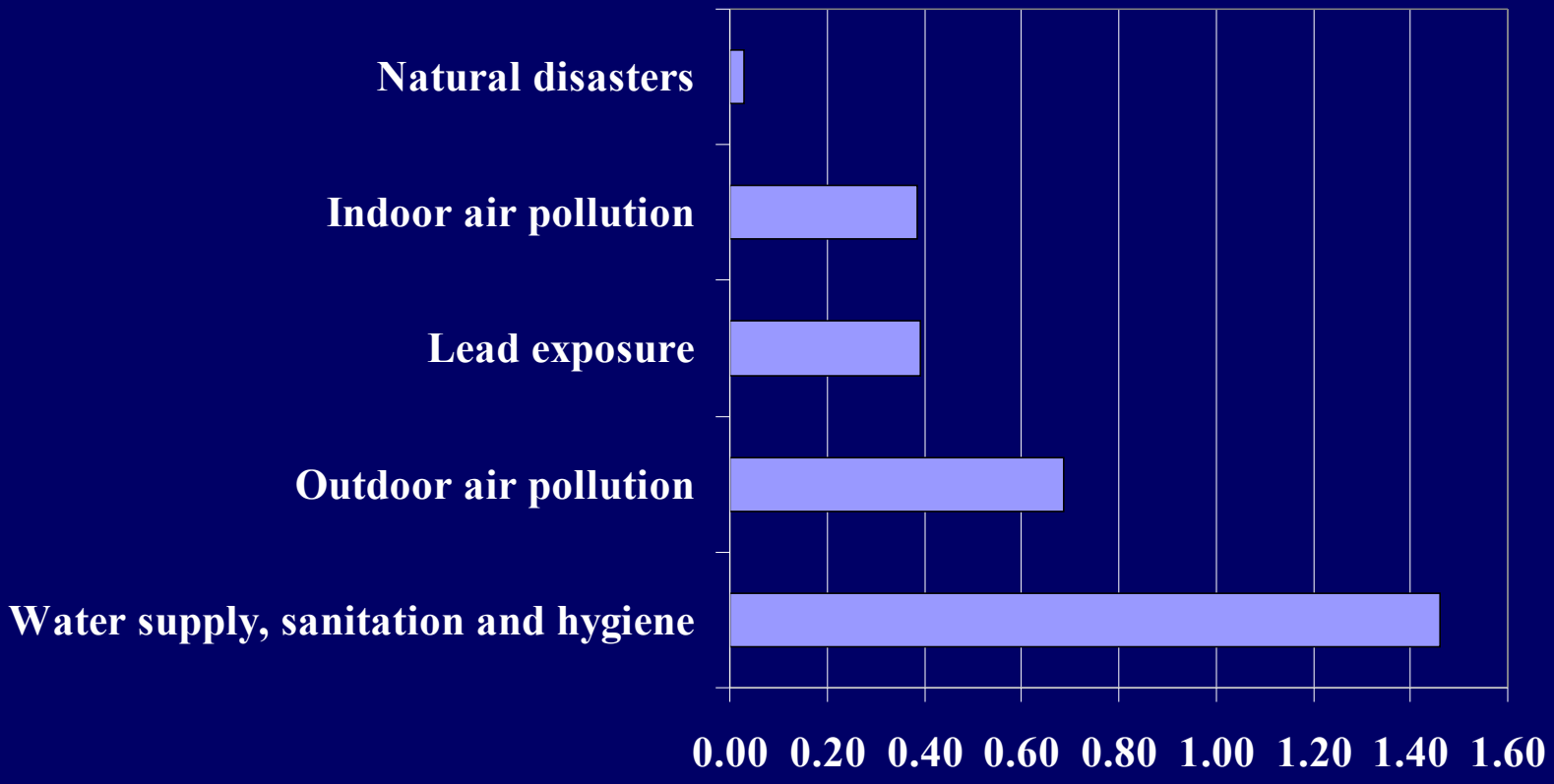
(Billion Soles per Year)



Number of Deaths By Category
(per Year)



Morbidity Costs By Category
(Billion Soles per Year)



Estimation of Health Damages

- *Urban Air Pollution and Indoor Air Pollution*:
  - Dose response functions from international studies
  - Analysis of IQs loss and attributable fraction of diseases for lead exposure
- *Inadequate Water-Sanitation-Hygiene*:
  - Household surveys and health statistics
- *Natural Disasters:*
  - Health statistics

Estimation of Physical Damages/Costs

- *Natural Disasters*:
  - Disaster statistics
- *Avertive behavior (drinking water)*:
  - Household and manufacturer surveys
- *Agricultural Land Degradation:*
  - Land use, effects on crop yield, crop prices
- *Overfishing:*
  - Fish catch, fishing fleet, econometrics
- *Deforestation:*
  - Deforestation statistics; benefit transfer

Valuation of Damages

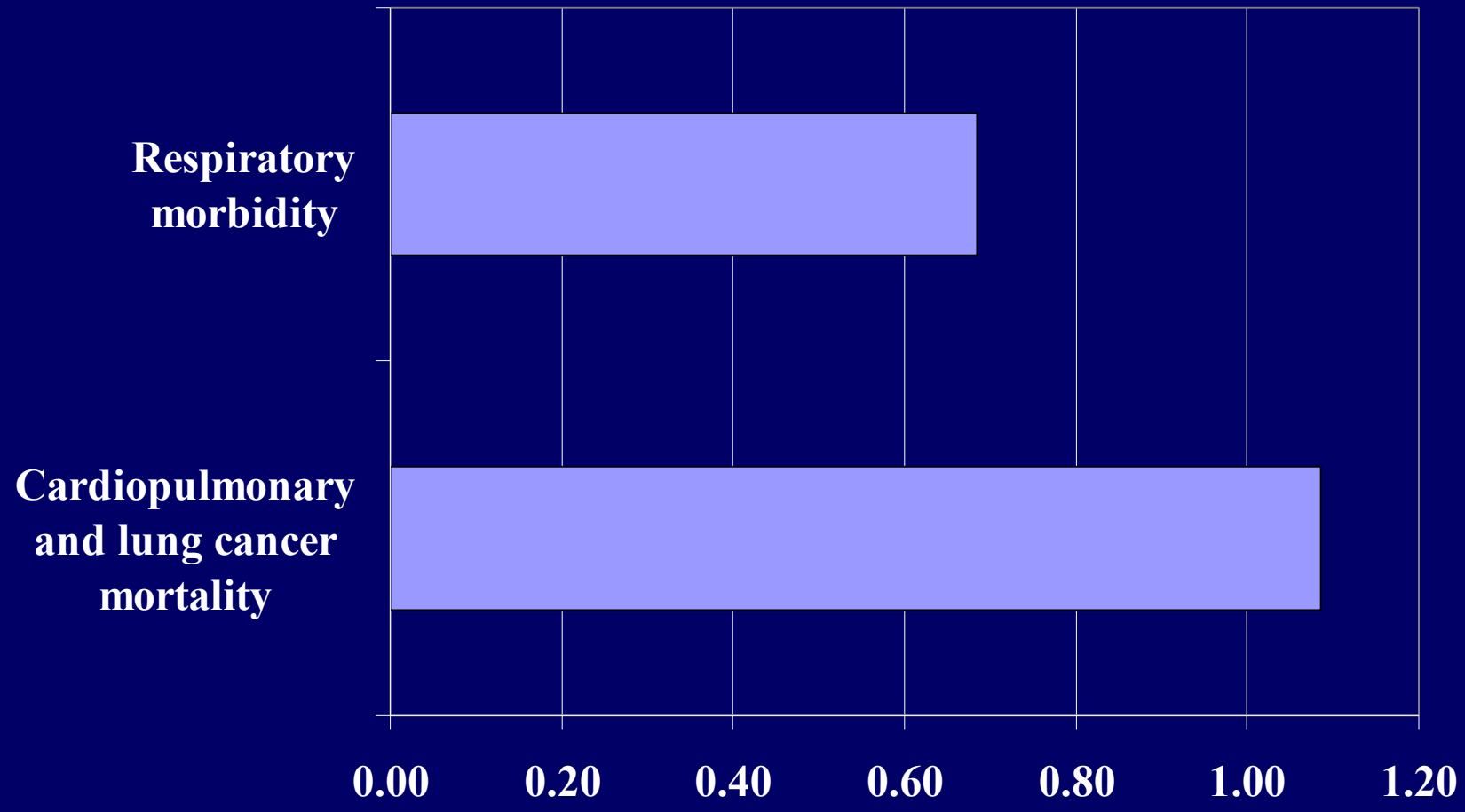
- MORTALITY: Human Capital Approach (HCA) and Value of Statistical Life (VSL)
- MORBIDITY: Cost-of-illness (treatment, medicines, time losses) and valuation of DALYs at GDP per capita
- PHYSICAL DAMAGES/COSTS: Market prices, Replacement costs, contingent valuation (CV)

URBAN AIR POLLUTION

- Particulates (PM) found to have the largest health impacts ---- therefore the focus of this study
- 50% of the population in Peru live in cities with > 100 thousand population
- 30% in Peru live in Lima-Callao
- WHO estimates 0.8 million deaths globally per year from PM
- Other Pollutants: Ozone, Sulphur, Nitrogen Oxides;
- Accumulated lead poisoning.

Cost of Urban Air Pollution

(Billion Soles per Year)



Procedure to Estimate Mortality

- Population exposed to Particulates (PM 2.5)
- Crude mortality rate (deaths per 1000)
- % of deaths due to Cardiopulmonary/Lung Cancer
- Dose Response Coefficient (Pope et al 2002)
- Annual Average Concentration of PM 2.5 (ug/m^3)
- Estimate Number of Deaths due to PM 2.5

Annual Deaths from PM 2.5

	PM 2.5 (ug/m3)	Annual deaths	Percent
Lima -Callao	51	2765	74%
Arequipa	38	223	6%
Trujillo	22	106	3%
Other cities	25	663	18%
Total		3757	100%

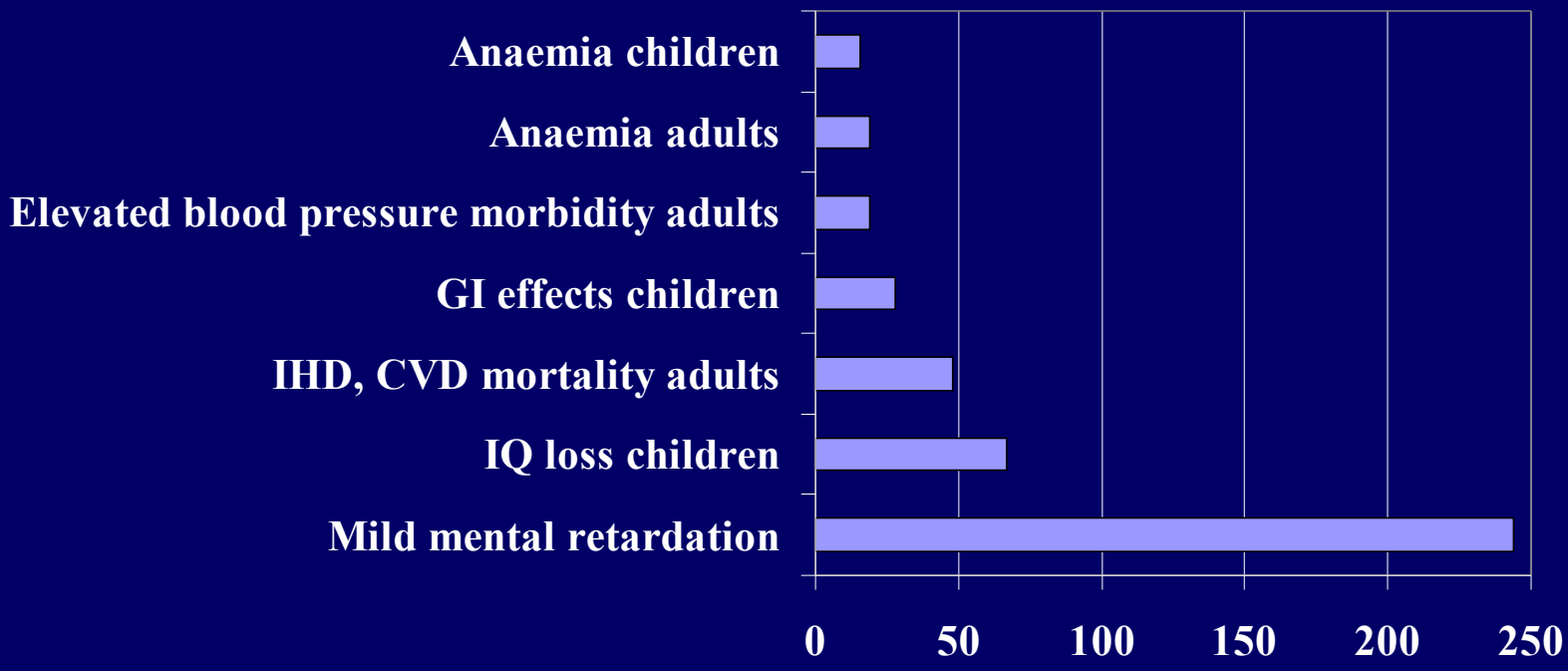
Health Damage from Lead Exposure

- At present: concentration of lead in the atmosphere is low;
- Lead is accumulated in the soil and water;
- Major indicator is lead concentration in blood;
- Adjustment for the successful lead phase out program.

Procedure to Estimate Mortality and Morbidity Related to Lead Exposure

- Review of the available lead blood level studies in Peru;
- Estimation of the weighted average lead blood level;
- Estimation of the attributable fractions of the relevant diseases and IQ loss;
- Estimation of the corresponding DALYs and mortality.

Annual Costs of Lead Poisoning (Million S/.)



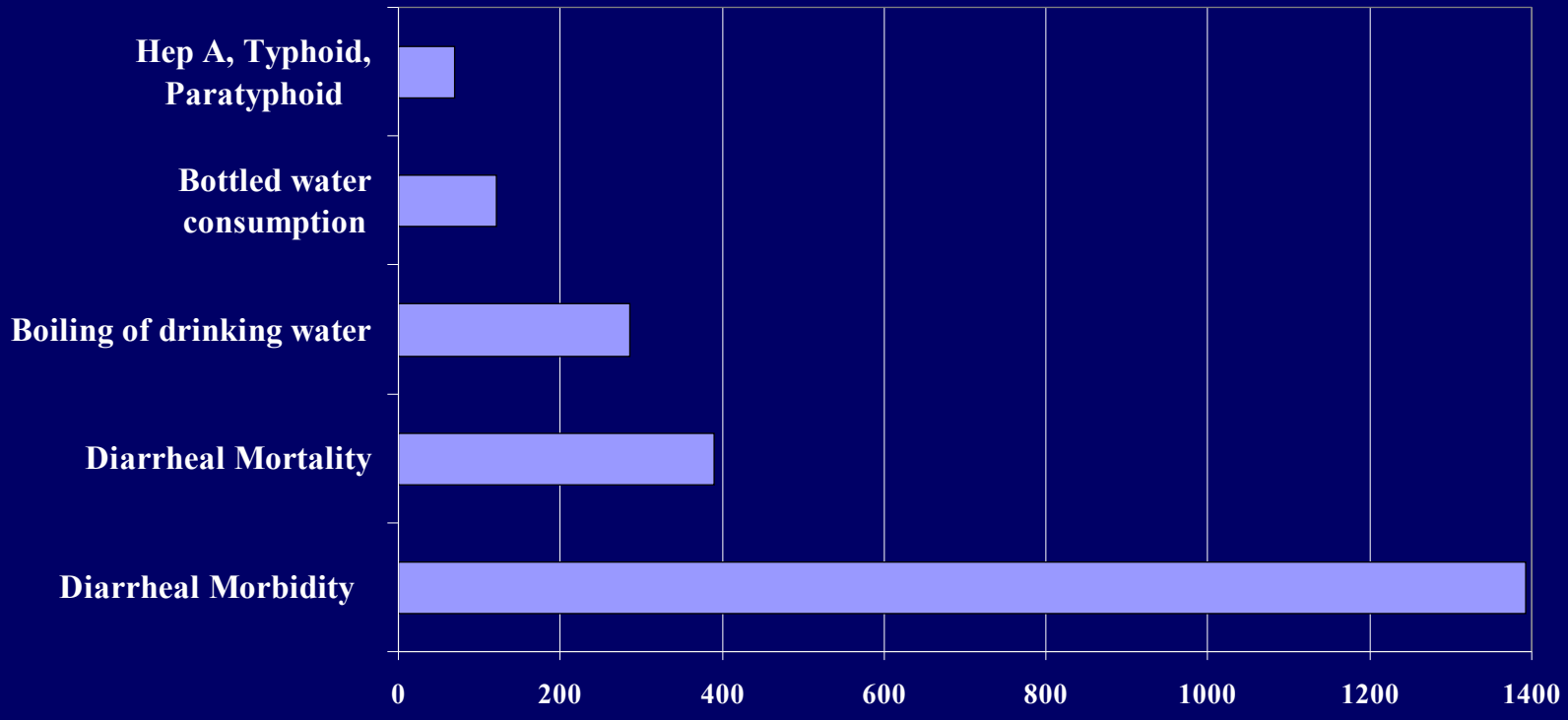
INADEQUATE WATER-SANITATION-HYGIENE

- Diarrheal mortality in children under-5 years
- Diarrheal morbidity in children and adults
- Avertive behavior (to avoid or reduce risk of illness)

- WHO global estimate: 1.7 million deaths and 4.4 billion cases of diarrheal illness per year.

Cost of Inadequate Water-Sanitation-Hygiene

(Million Soles per Year)



Procedure to Estimate Health Impacts

- Mortality data from Ministry of Health
- Estimate annual cases of diarrheal illness:

  -Children under-5: From diarrheal prevalence (Peru DHS 2000)

  -Population over-5: Peru DHS 2000 and INS (Columbia) data bases
- 90% of diarreal illness is from inadequate water-sanitation-hygiene (WHO global burden of disease)

Baseline Data

- Diarrheal mortality in children under 5: about 9 % of child mortality (based on WHO and Ministry of Health data)
- Estimated Diarrheal incidence:

  3.2 per child per year (based on DHS 2000)

  0.46-0.63 per year per person over-5 years (based on DHS 2000 and INS data base)

Estimated Annual Cases

(Inadequate Water-Sanitation-Hygiene)

	Cases per Year
Diarrheal child mortality	850-2400
Diarrheal morbidity in children under 5	9.3 million
Diarrheal morbidity in population over 5	13 million

Annual Costs of Health Impacts

(Inadequate Water-Sanitation-Hygiene)

	Million Soles per Year
Child Mortality	200-580
Cost of medical treatment (doctors, clinics, hospitals)	590
Cost of medicines	318
Cost of time losses	315-490
Total	1699

The range of cost of time losses reflects a duration of illness of 3-4 days, and a range in annual cases of diarrheal illnesses (20-25 million)

Annual Costs of Avertive Behavior

(Inadequate Water-Sanitation-Hygiene)

	Million Soles per Year
Cost of boiling drinking water (0.5-1.0 liter per day)	190-380
Cost of bottled water (0.5-2.5 Soles per liter)	75-170
TOTAL	265-550
Note: 69 % of households boil their drinking water	

INDOOR AIR POLLUTION

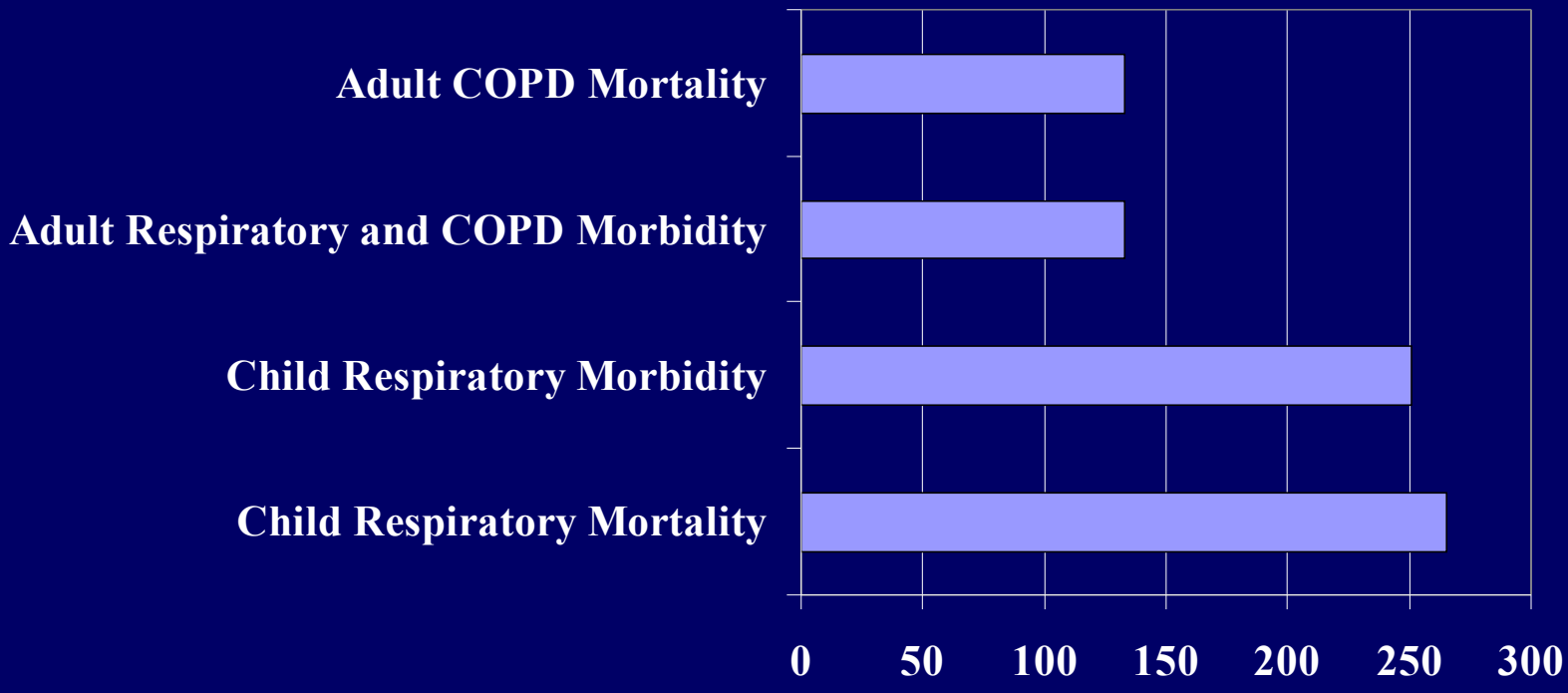
- Particulates (PM) from solid fuels (wood, charcoal, coal etc) used in the indoor environment (cooking, heating)

- In households using solid fuels: PM levels are often many times higher than in the outdoor urban environment

- WHO estimates 1.6 million deaths globally per year

Cost of Indoor Air Pollution

(Million Soles per Year)



Procedure to Estimate Health Impacts

- Population using solid fuels (87 % of rural households, 10% of urban households)
- Odds ratios (Desai, 2004): COPD 2.3-4.8
  ARI 1.9-2.7
- Baseline COPD and ARI incidence

Baseline Data

- Female COPD deaths: 2 % of all deaths (WHO)
- Female COPD incidence: 33 per 100 000 (WHO)

Rural Data:

- ARI mortality in children under 5: about 15% of child mortality (based on data from Ministry of Health and WHO)
- ARI incidence: 3.6 per child per year (based on Peru DHS 2000)
- ARI incidence: about 0.6-0.68 per year per adult female (based on DHS 2000 and INS data base)

Estimated Annual Cases
(Indoor Air Pollution)

	Cases per Year
ARI Child mortality (under 5)	910-1290
ARI Child morbidity (under 5)	2.1-3.1 million
ARI morbidity (females over 30)	0.55-0.83 million
COPD mortality (females over 30)	335-600
COPD morbidity (females over 30)	925-1670

Annual Costs of Health Impacts

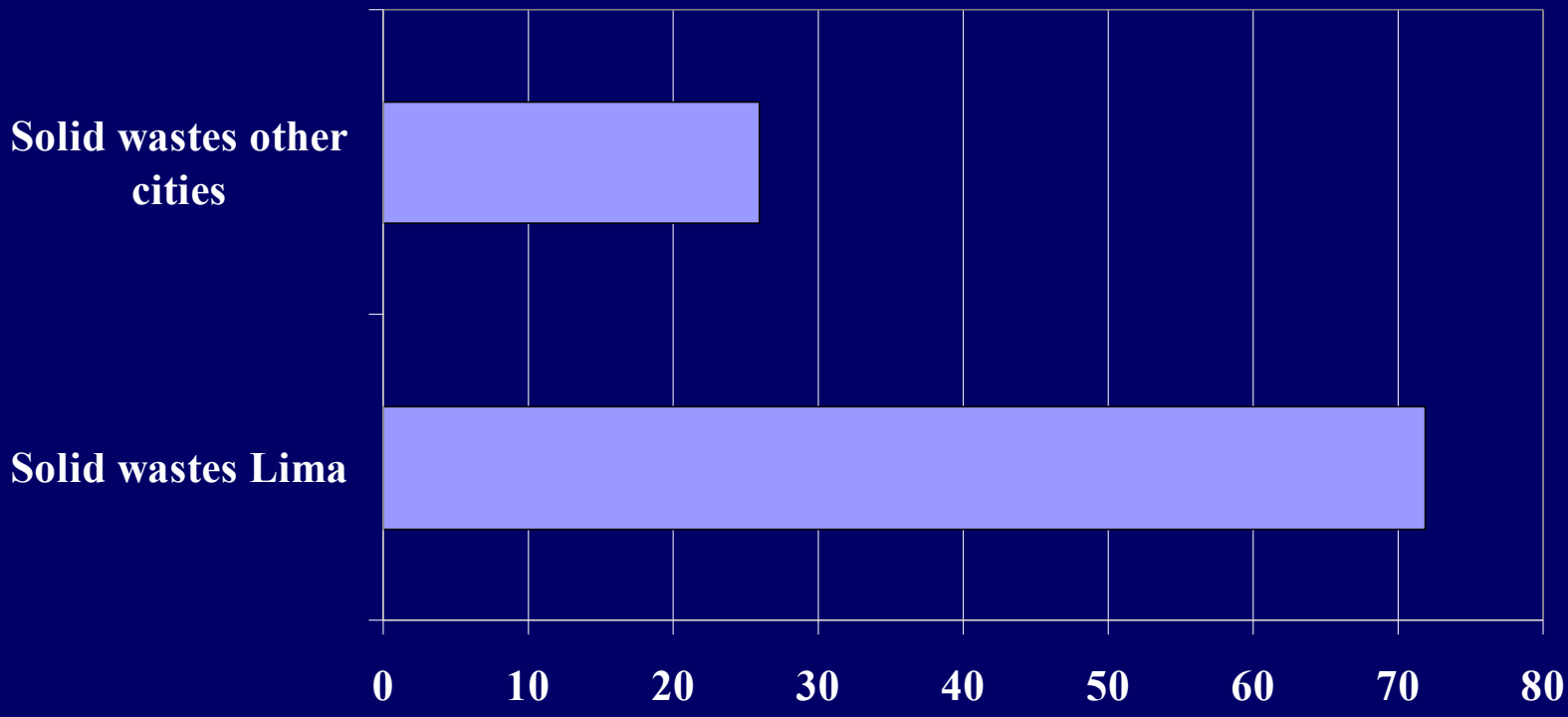
(Indoor Air Pollution)

	Million Soles per Year
Child mortality	220-310
COPD adult female mortality	20-245
Cost of medical treatment (hospital, clinics, doctors)	85-135
Cost of medicines	50-80
Cost of time losses	90-140
TOTAL	465-910
Note: Does not include valuation of DALYs for morbidity	

MUNICIPAL WASTE COLLECTION

- 70 percent of municipal waste is collected in urban areas (CONAM);
- No information available about willingness to pay (WTP) for waste collection in Peru;
- Application of benefit-transfer approach.

Annual Cost Of Inadequate Municipal Waste Collection (Million Soles)

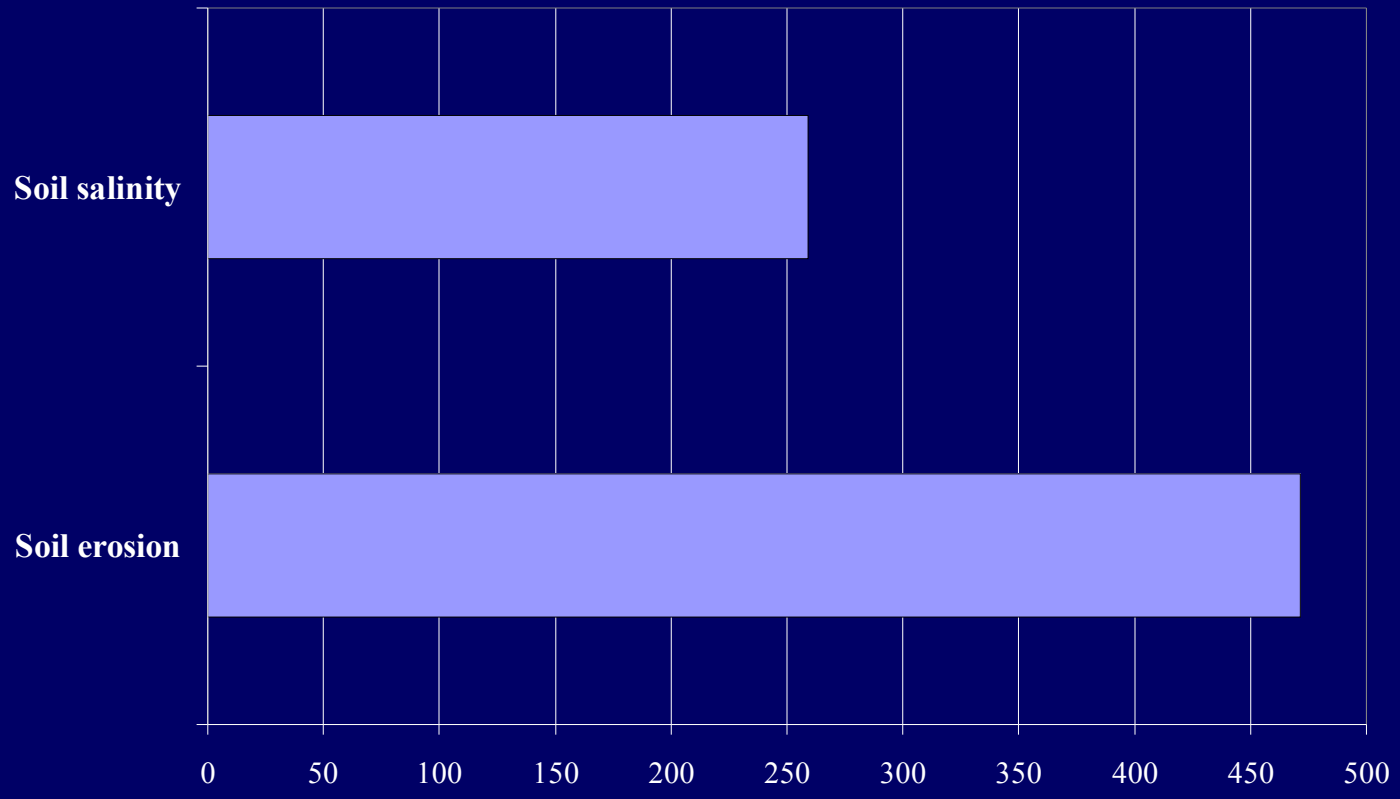


SOIL DEGRADATION

- Agricultural Soil salinity: Especially the Costa region
- Agricultural Soil erosion: Widespread in many parts of Peru, but the most severe in Sierra
- Rangeland degradation: Inadequate information/data

Cost of Soil Degradation

(Million Soles per Year)



Agricultural Soil Salinity

- Saline soils: 300 thousand hectares
- Abandoned land: 1/3rd (assumption)
- Rice yield: 15-30% reduction
- Cotton yield: 10-25% reduction

Cost of Soil Salinity

		Low	High
Annual losses due to abandoned lands	Million S.	32	97
Annual loss of rice production	Thousand tons	179	357
Annual lost output value of rice	Million S./	98	196
Annual loss of cotton production	Thousand tons	10	33
Annual lost output value of cotton	Million S./	22	72
Total annual lost output	Million S./	152	365

Agricultural Soil Erosion

- Indication that 60% of agric land in Sierra is eroded (800 out of 1300 thousand hectares
- Very little data, so estimating erosion cost as difference in yield on terraced and non-terraced land (for potatoes and corn)
- Annually cultivated land that could be improved: 45% of 800 thousand

Cost of Agric Land Erosion in Sierra

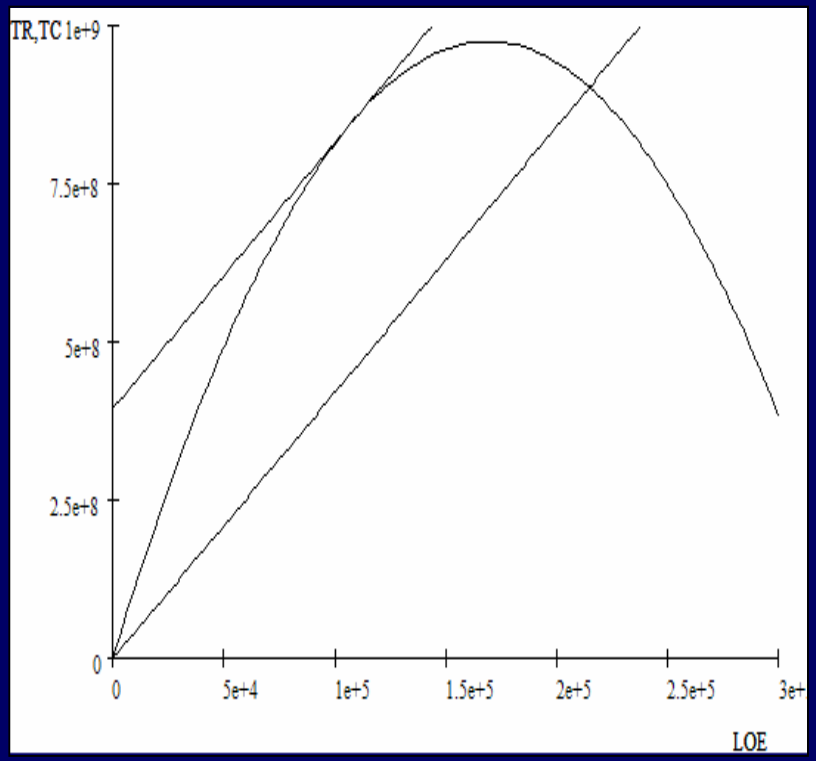
(million Soles per year)

Region	Low	Mean	High
Northern	48	128	209
Central	287	287	287
Southern	57	57	57
TOTAL	392	472	553

OVERFISHING

- The most important anchovy fishery biomass peaked in 1970;
- Economic over-fishing occurs when increases in fishing effort lead to decrease in profit levels below maximum;
- Econometric analysis of catch per unit of efforts;
- Data from The Peru Fishery Strategy 2003

The economic cost of over-fishing are estimated at 757 million S/. per year



- Estimation of optimal fish catch;
- Approximation of Total Revenue and Total Cost;
- Fishing effort exceeds optimal economic point by 70% and max sustainable point by 10 %

Key Indicators

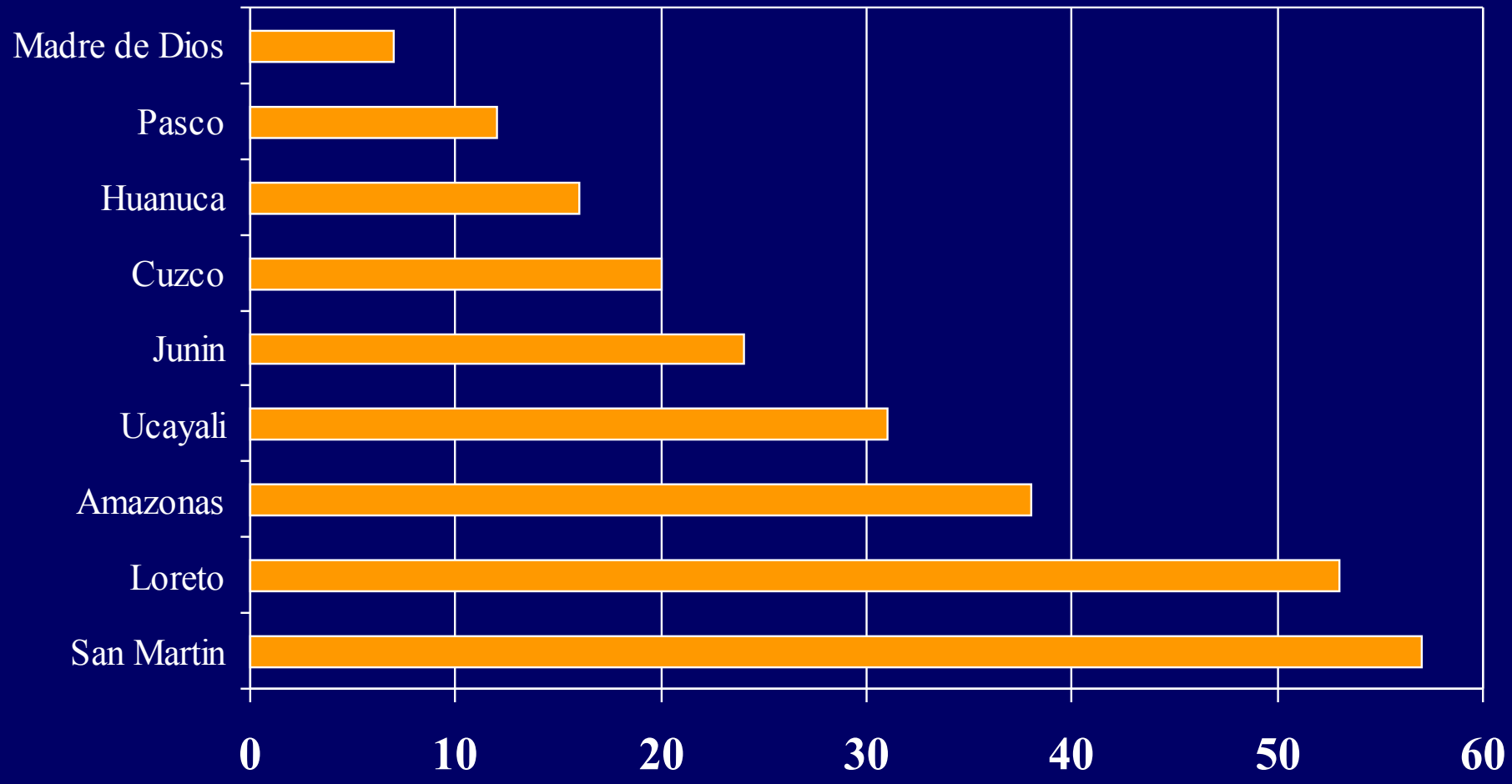
	Volume of Catch (Million MT)	Total Revenue (Million US $)	Level of Effort (fishing fleet capacity)	Total cost (Million US $)	Economic Rent (Million US $)
Maximum sustainable point	7.03	970	168660	700	270
Maximum economic point	6.14	840	107350	450	390
Open access point	6.45	890	214690	890	0
Predicted fishery sector indicators (2002)	6.95	950	185000	780	170
Annual Lost Profit					220

DEFORESTATION

- Original forest cover is about 59 % of total land area;
- In 2000 forest cover is about 50 % of total land area (INRENA);
- Deforestation losses occur on the global, national, regional and local level;
- National and regional costs are included in the cost of natural disasters (increased frequency and severity of flooding and landslides), and agricultural land erosion. It is very difficult to estimate these costs.

Annual Deforestation 1985-2000

(000 hectares)



Annual Values of Forest Benefits in the Amazon Forest (US$ Per Hectare)

	US$ per hectare
Direct use values	**31-56**
Sustainable timber	20-30
Non timber products	9-17
Tourism and recreation	2-9
Indirect use values	**258-860**
Carbon storage	258-860
Non-use values	**3-51**
Option value (bioprospecting)	2-20
Existence value	1-31
Total value	**292-967**

Economic Cost of Deforestation

	Million Soles
Total Annual Deforestation Cost	270-880
Direct use cost (local cost)	30-50 (5-9%)
Note: Indirect use values are subject to climate negotiations (compensation for reduced deforestation)	

NATURAL DISASTERS

- Peru is affected by two categories of natural disasters:

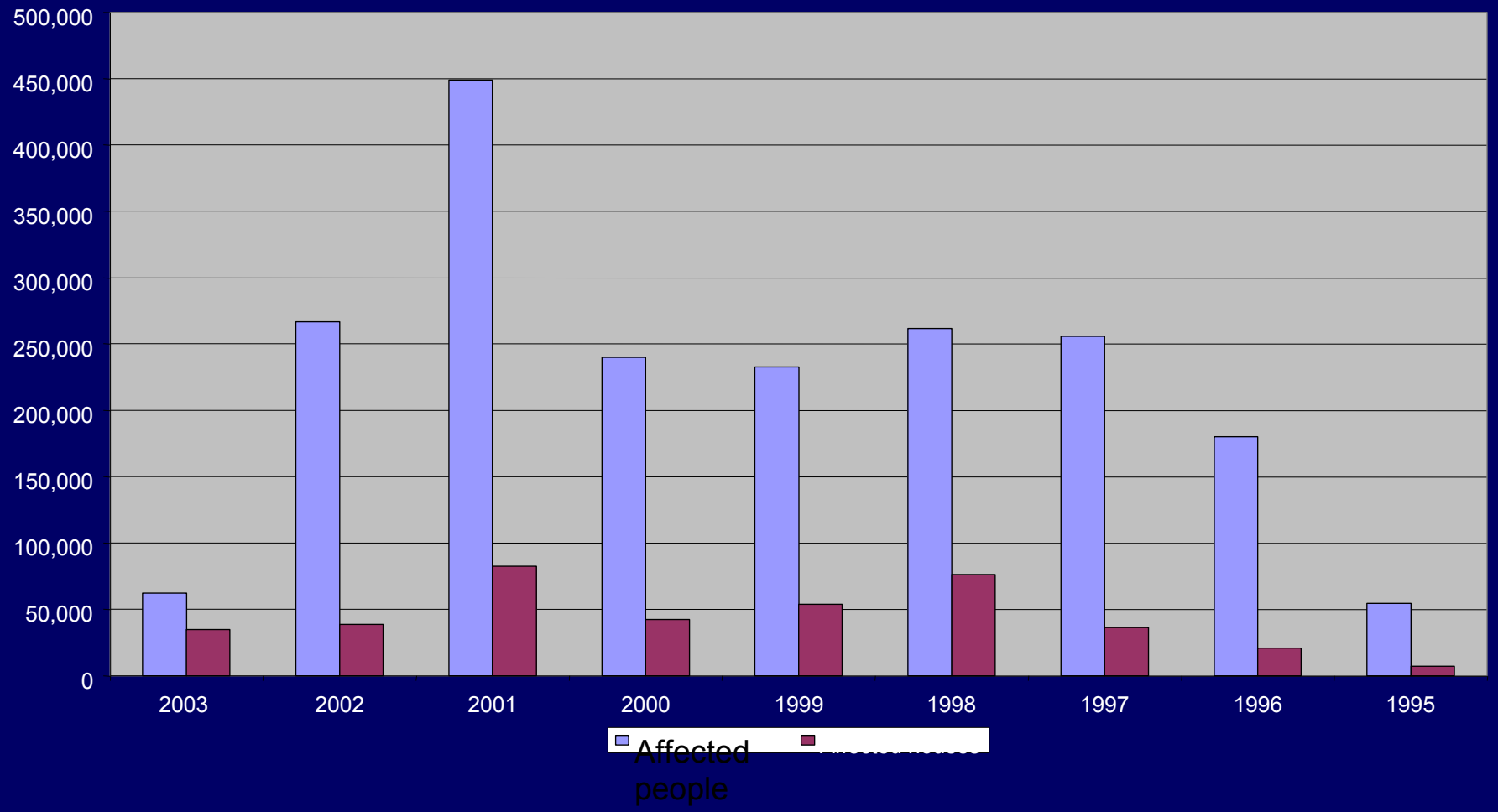
  - “Frequently” occurring disasters (such as floods, land slides, avalanches, storms, droughts, fires

  -”Periodically” occurring disasters (major earthquakes)

Procedure to Estimate Cost of Natural Disasters

- Data base on natural disasters from Defensa Civil y Dirección Nacional de Operaciones del INDECI – SINPAD;
- Existing cost estimates by Bambaren Alatrista (2002), which were developed to valuate the El Nino damage;
- Derivation of unit cost estimates from the above cost study, to estimate cost of other types of disasters

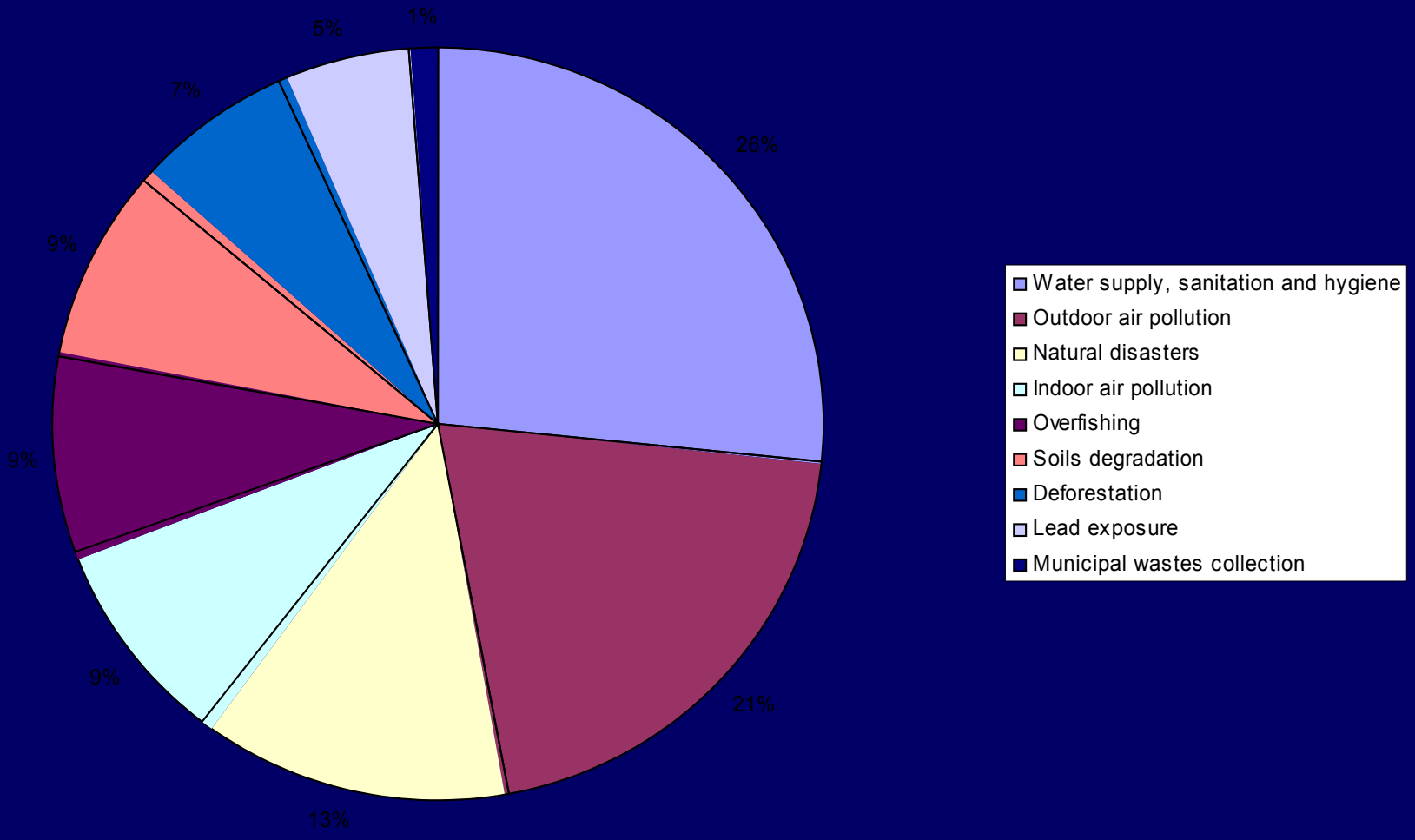
Number of Affected People (blue) and Houses (red)



Annual Cost of Natural Disasters (1990-2003)

	Million Soles
Deaths*	45
Injured	29
Missing persons	9
Houses destroyed	327
Houses affected	536
Hectares destroyed	69
Roads destroyed, affected	34
Railroads destroyed, affected	3
Bridges destroyed, affected	21
TOTAL COST	1074

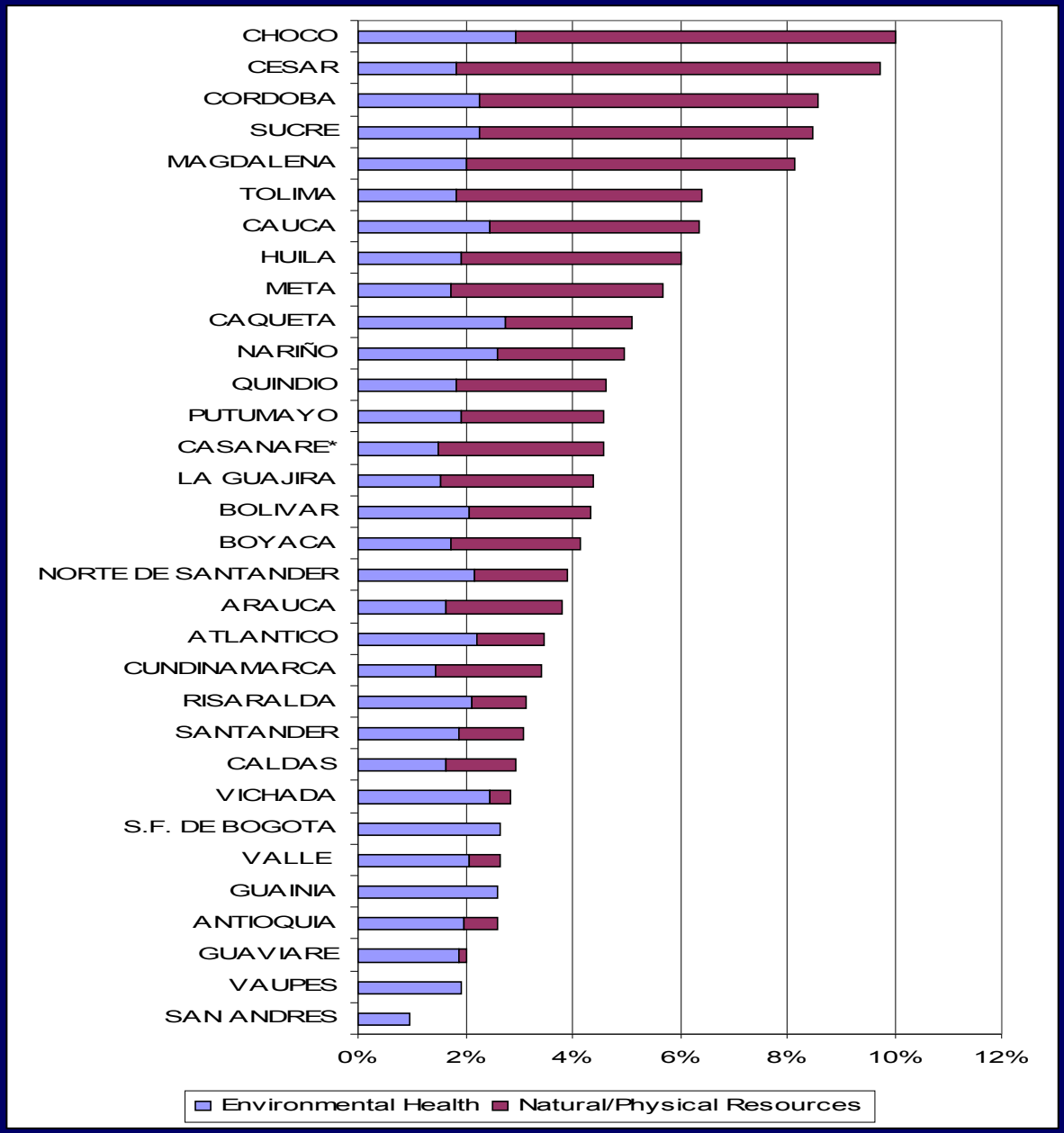
Cost of Damage (% by category)



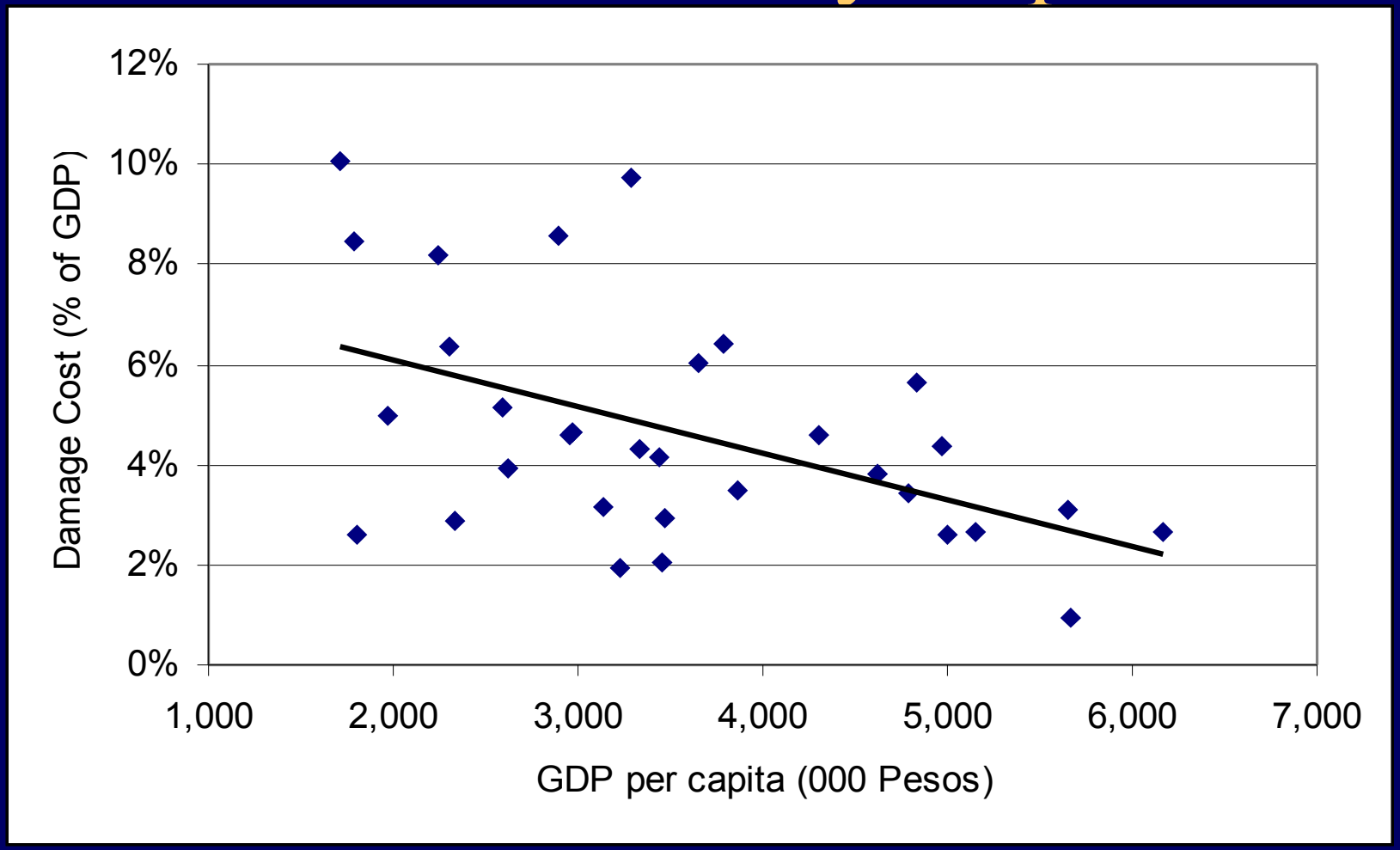
Damage Cost Estimates in Other Countries

	% of GDP
Egypt	4.8 %
Colombia (with natural disasters)	3.75%
Morocco	3.7 %
Algeria	3.6 %
Lebanon	3.4 %
Syria	3.3 %
Jordan	3.1 %
Tunisia	2.1 %
Peru (with natural disasters)	***4.05 %***

Cost of Environmental Damage in Colombia (% of GDP)



CED in Colombia by Department



CED in Colombia by Department

	Income Elasticity	t-statistic	R^2	
Urban Air Pollution	0.7	2.3	0.21	
Water-Sanitation-Hygiene	-0.7	-11.4	0.81	
Indoor Air Pollution	-1.5	-3.3	0.26	
Agricultural Land Degradation	-1.3*	-1.6*	0.10	
Natural Disasters	-1.8	-2.3	0.15	
ALL CATEGORIES	-0.7	-3.0	0.23	

* Not statistically significant