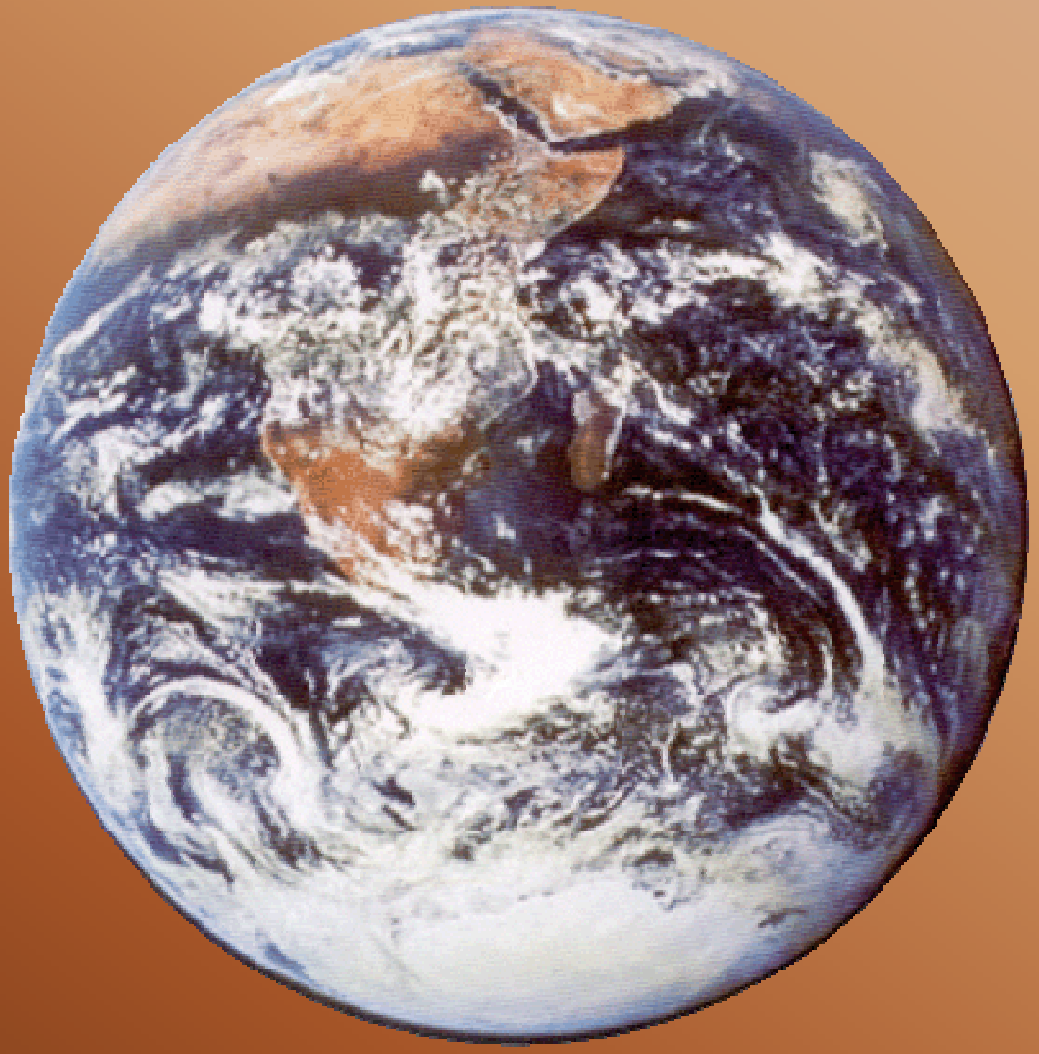
The Future of Energy
and
Energy for the Future

IAEA, Vienna
15 September 2009

Ashok Khosla
Development Alternatives
and IUCN, Club of Rome, ZERI

Living Together ...



Development Alternatives

Energy Justice – Energy Security for All

Energy Security


cul
VON TROJAN
SOUVENIRS
OPALS

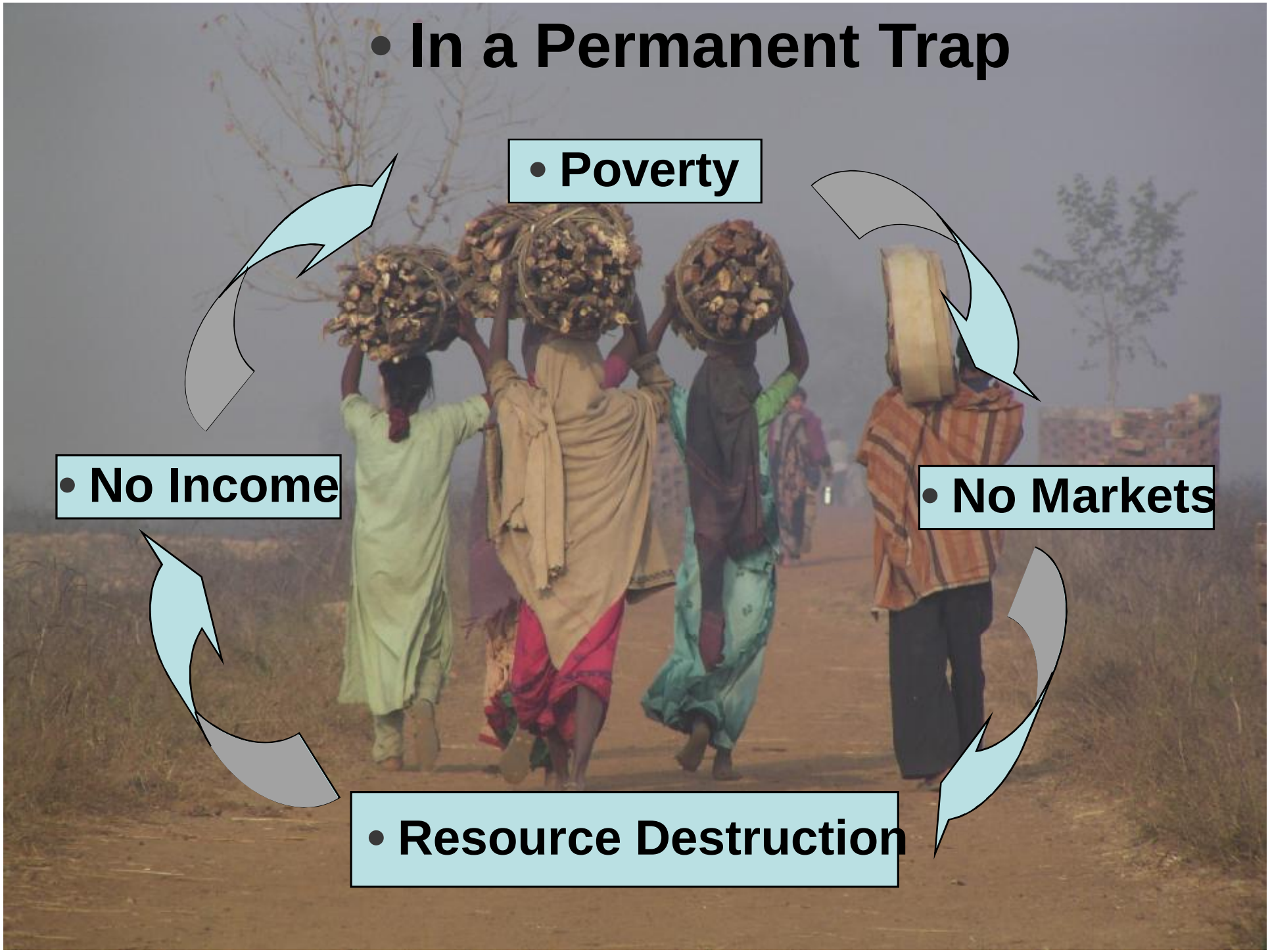
Development Alternatives

... Shelterless in the Village


Sustainable Energy for Our Children


Every Drop
Counts !

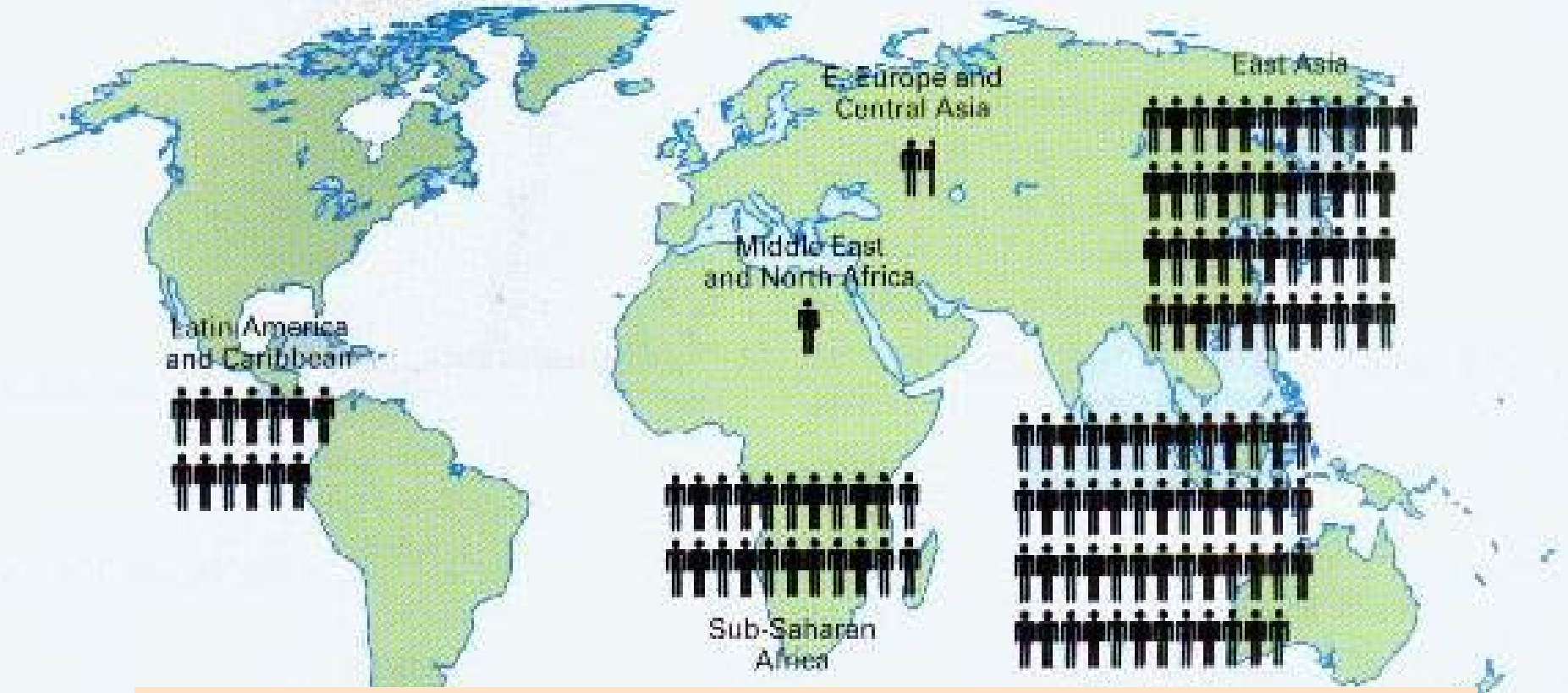

> 1,300 million people
– No Clean Drinking Water


• In a Permanent Trap
• Poverty
• No Markets
• Resource Destruction
• No Income


1,500,000 !

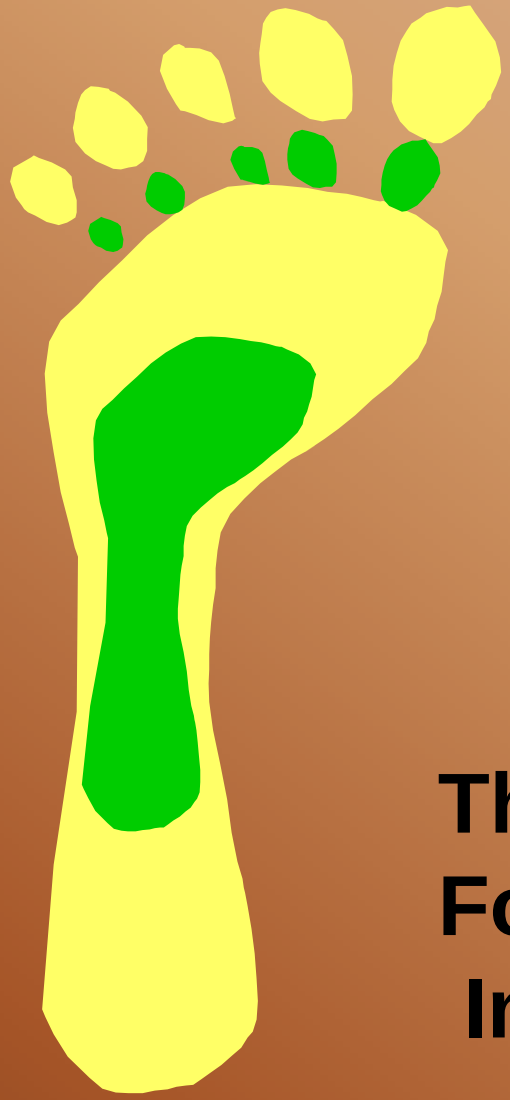
Poverty – 3 Billion

Each figure represents 10 million persons living on $1 a day or less at 1985 prices.



900 million people in Asia-Pacific are poor and it is 70% of the worlds poor people.

- (Source World

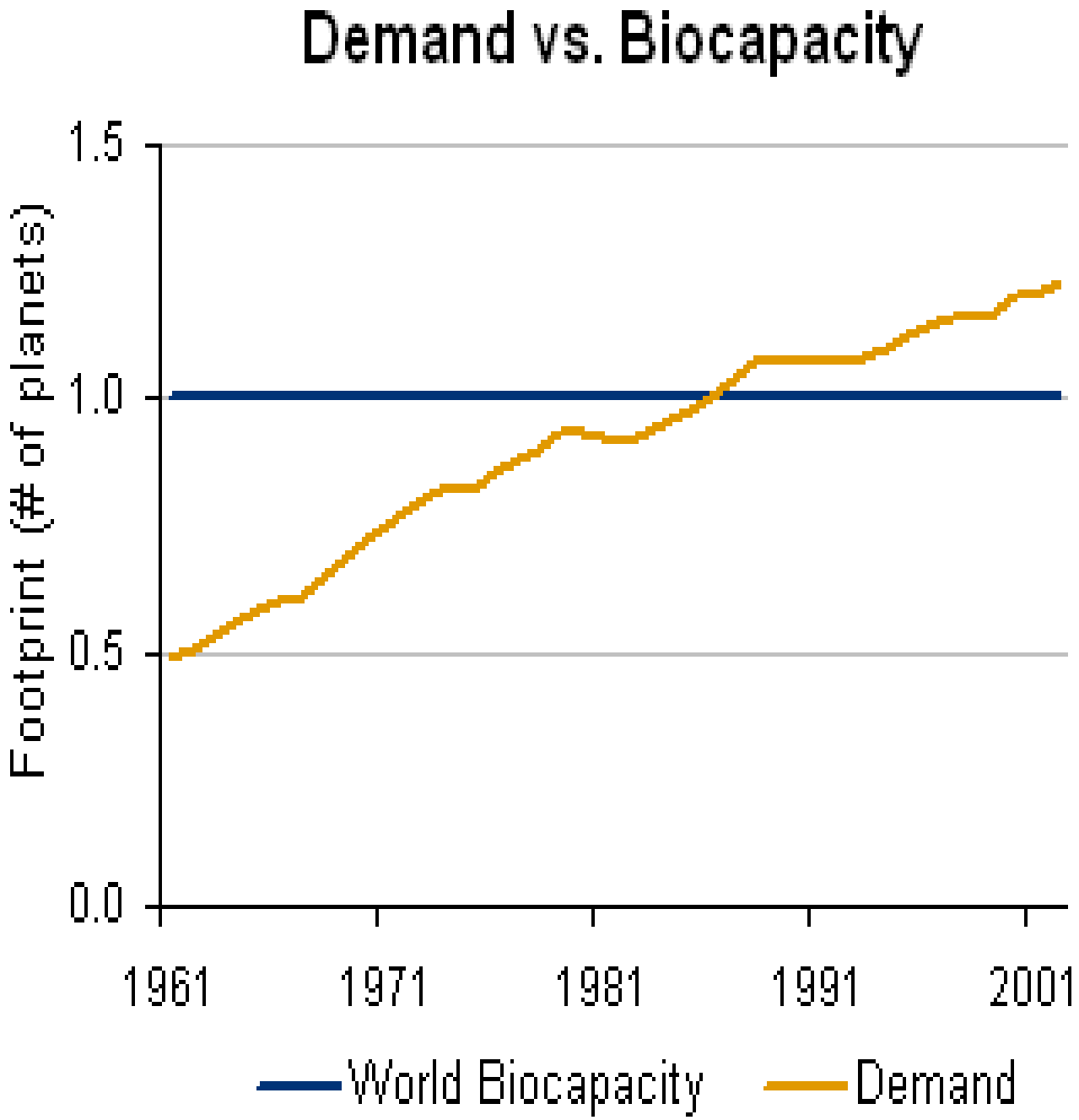


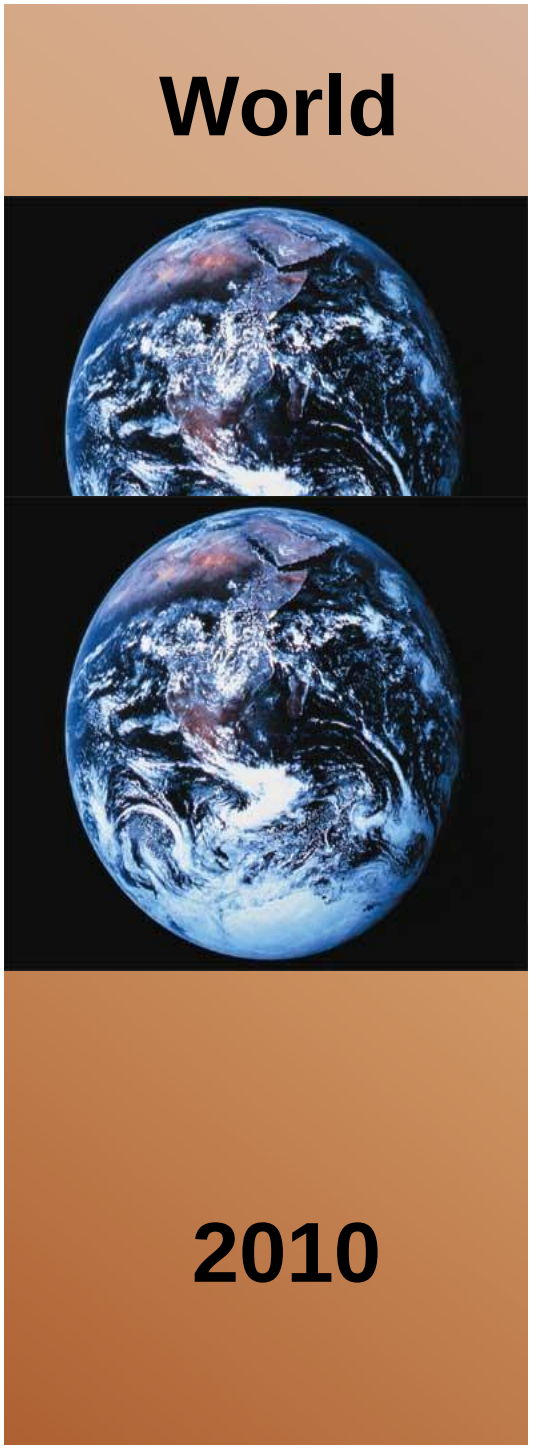
Footprint

Bio-Capacity

The Ecological Footprint of an Industrialized Country

Development Alternatives


Demand vs. Biocapacity
Footprint (# of planets)
1.5
1.0
0.5
0.0
1961
1971
1981
1991
2001
World Biocapacity
Demand


World
2010

Living Together ?

Development Alternatives

Energy for the Future

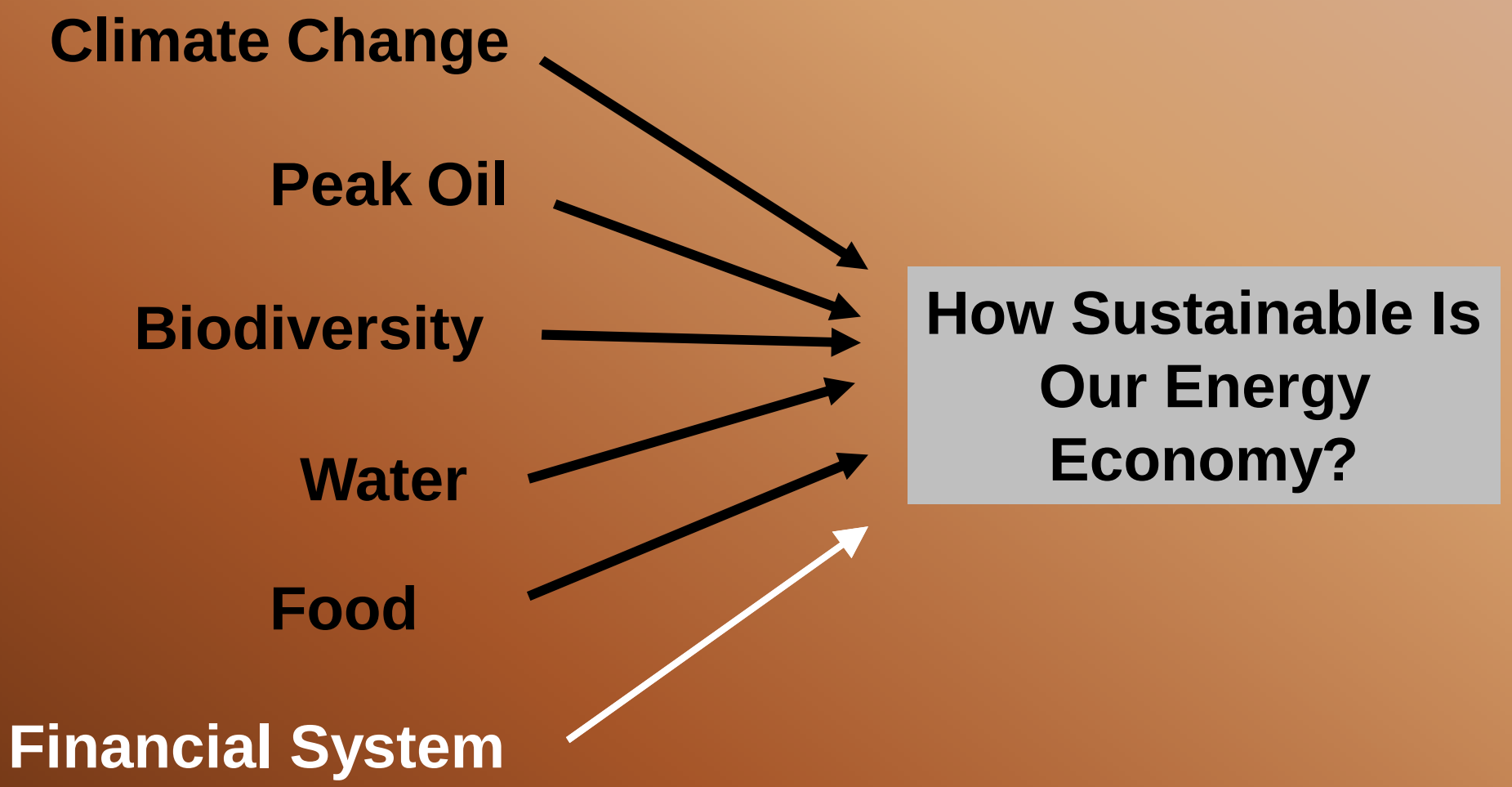
Energy is ONE Part of a VERY LARGE Global EcoSystem

Development Alternatives

The Energy Problematique

- Ø Energy for What ?
- Ø Energy for Whom ?
- Ø Energy from Where ?

The Immediate Convergence



Development Alternatives


National Development
. . . for whom?

Energy Sources

- Conventional
  - Fossil Fuels – Oil, Gas, Coal, etc
  - Nuclear
  - Large Hydro
- Future
  - Solar
  - Wind
  - Geothermal, Ocean
  - Small Hydro

Energy Efficiencies - Conservation

- Rated Efficiencies
  - First Law – Saving, HK
- Potential Efficiencies
  - Second Law – Appropriate Use
- Latent Efficiencies
  - Different technologies
- Systemic Efficiencies
  - Different Lifestyles

Energy Applications

- Ø Power Generation
- Ø Transport
- Ø Construction
- Ø Lighting, Cooking, Heating

Energy and Other Resources

People, Economics, Resources and the Environment

Development Alternatives

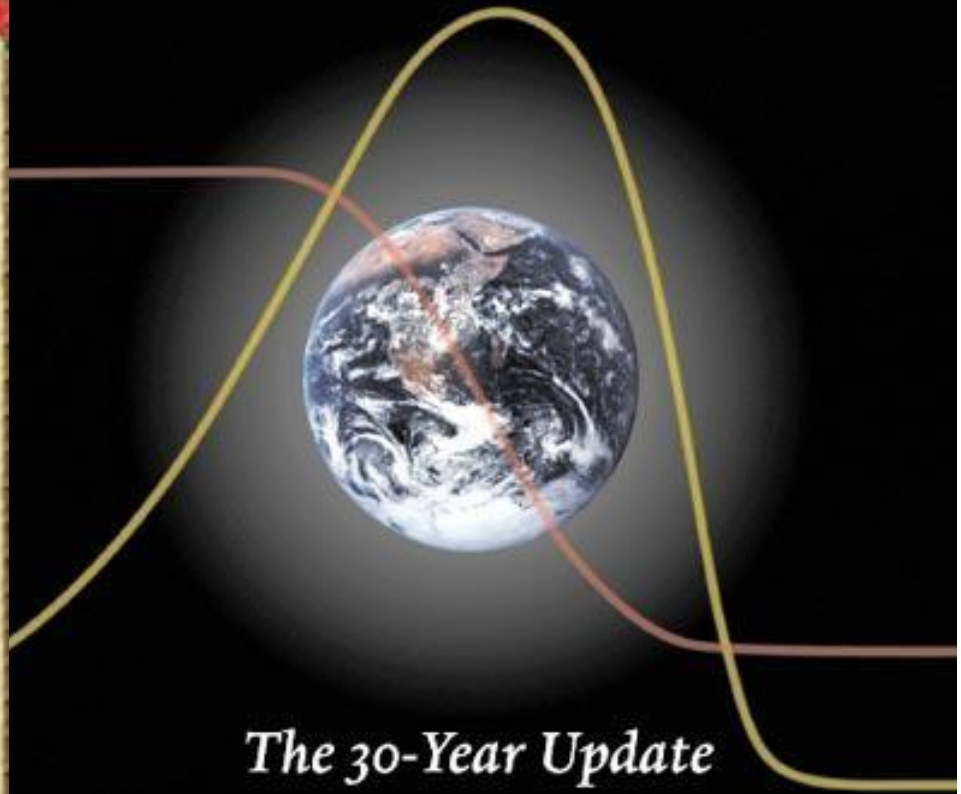
Pan

A report for the CLUB OF ROME'S project on the predicament of mankind.

THE LIMITS TO GROWTH

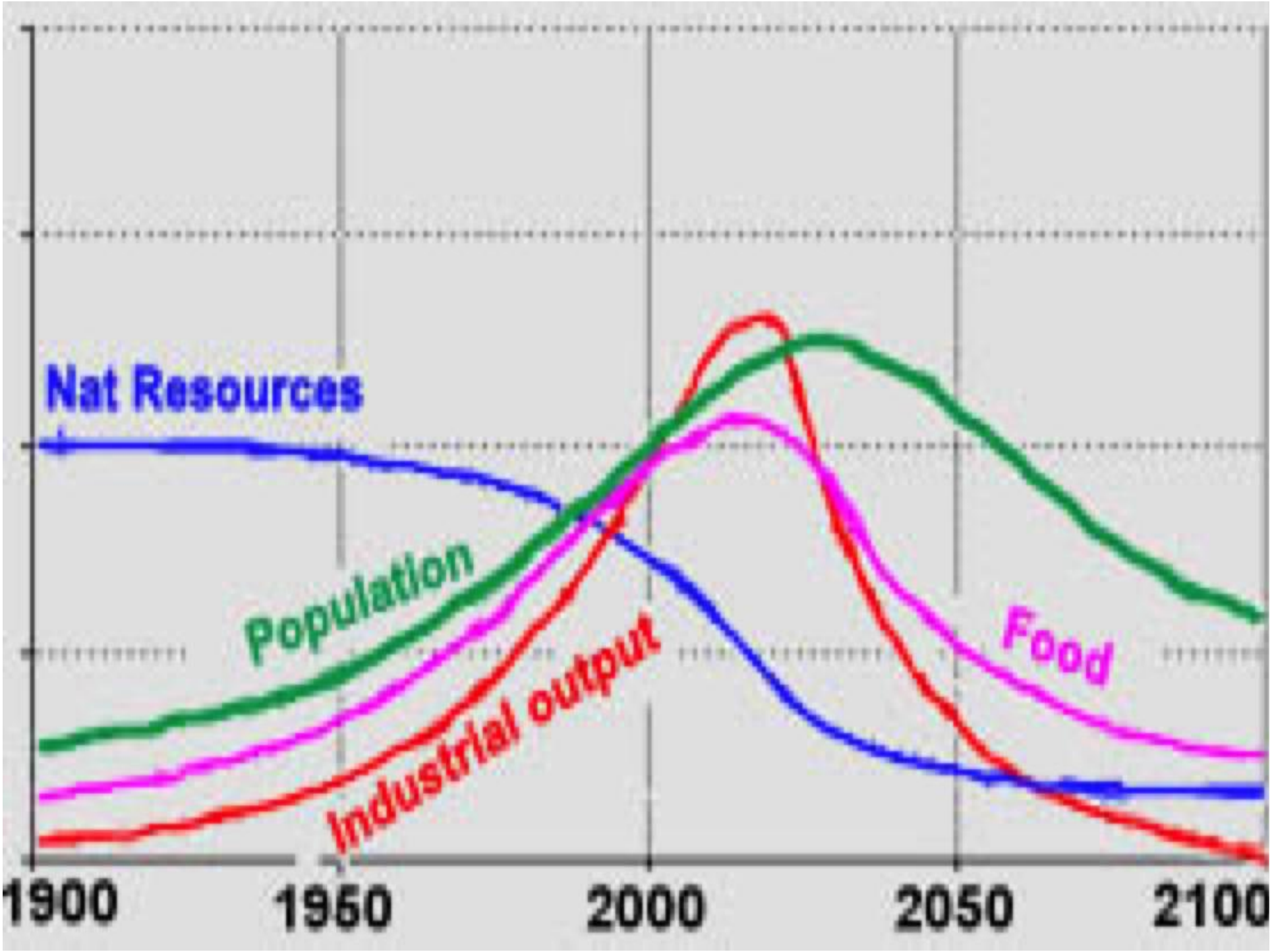
Donella H. Meadows Dennis L. Meadows
Jorgen Randers William W. Behrens III

LIMITS TO GROWTH



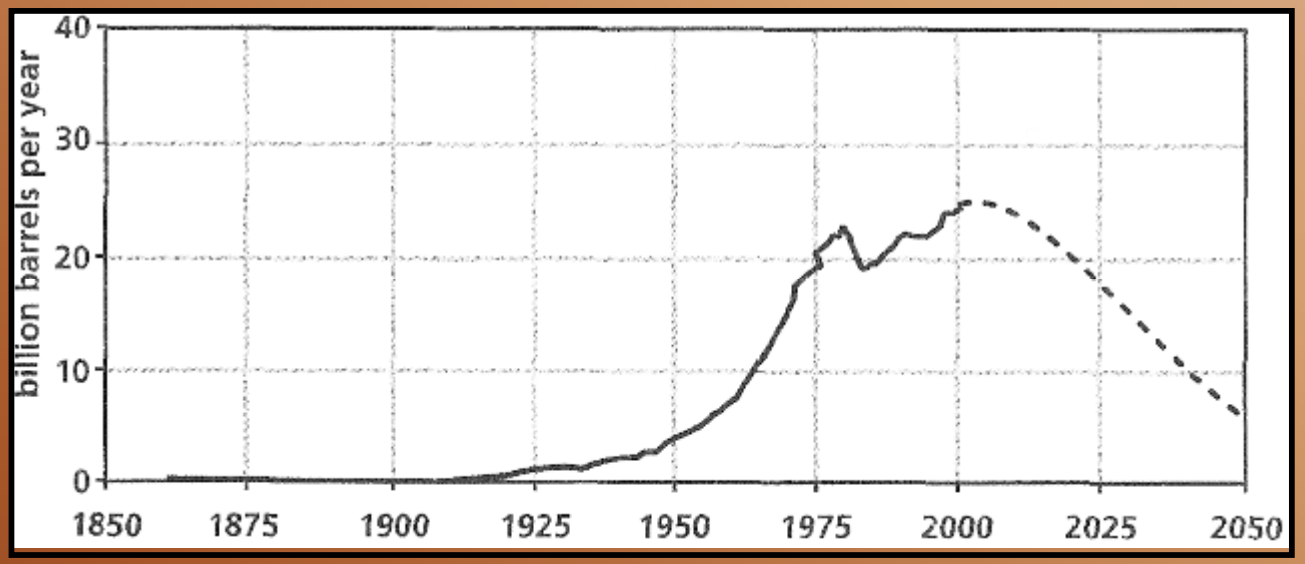
The 30-Year Update

DONELLA MEADOWS | JORGEN RANDERS | DENNIS MEADOWS


Nat Resources
Population
Industrial output
Food
1900
1950
2000
2050
2100

Oil and gas peaks

Oil production peaks before 2020

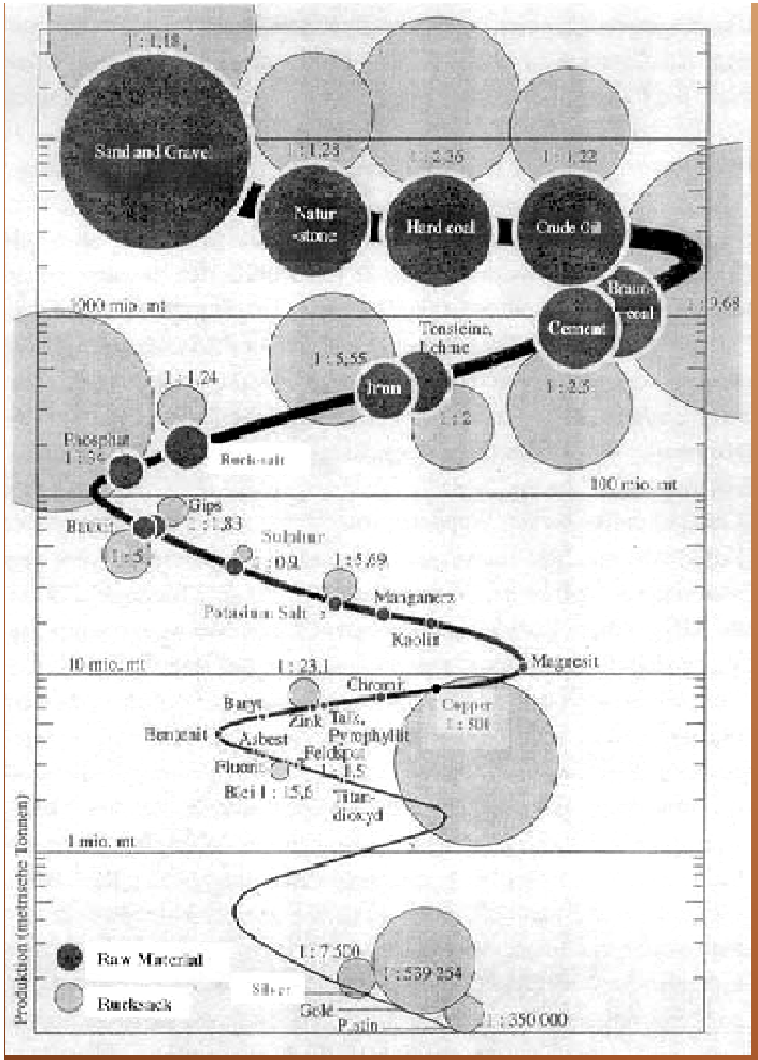


Source: Defeyes, 2001: Hubbert's Peak

Gas

Econ. growth (%)	0	2,8	5
Year of depletion	2260	2075	2055

Source: Meadows *et al.* 2004: Limits to Growth - The 30-Year Update



Ecological Rucksacks

Raw Material

Rucksack

Development Alternatives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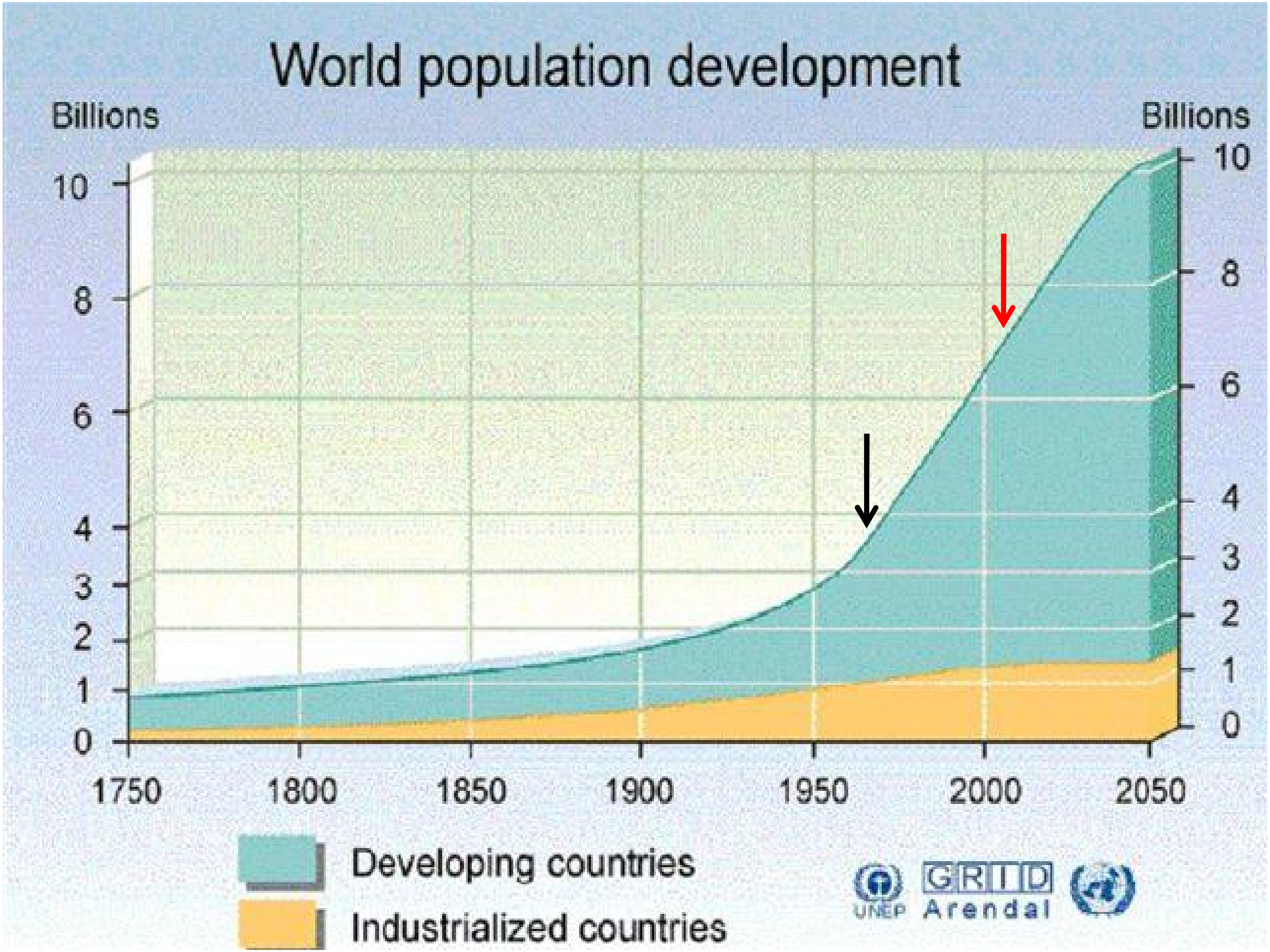
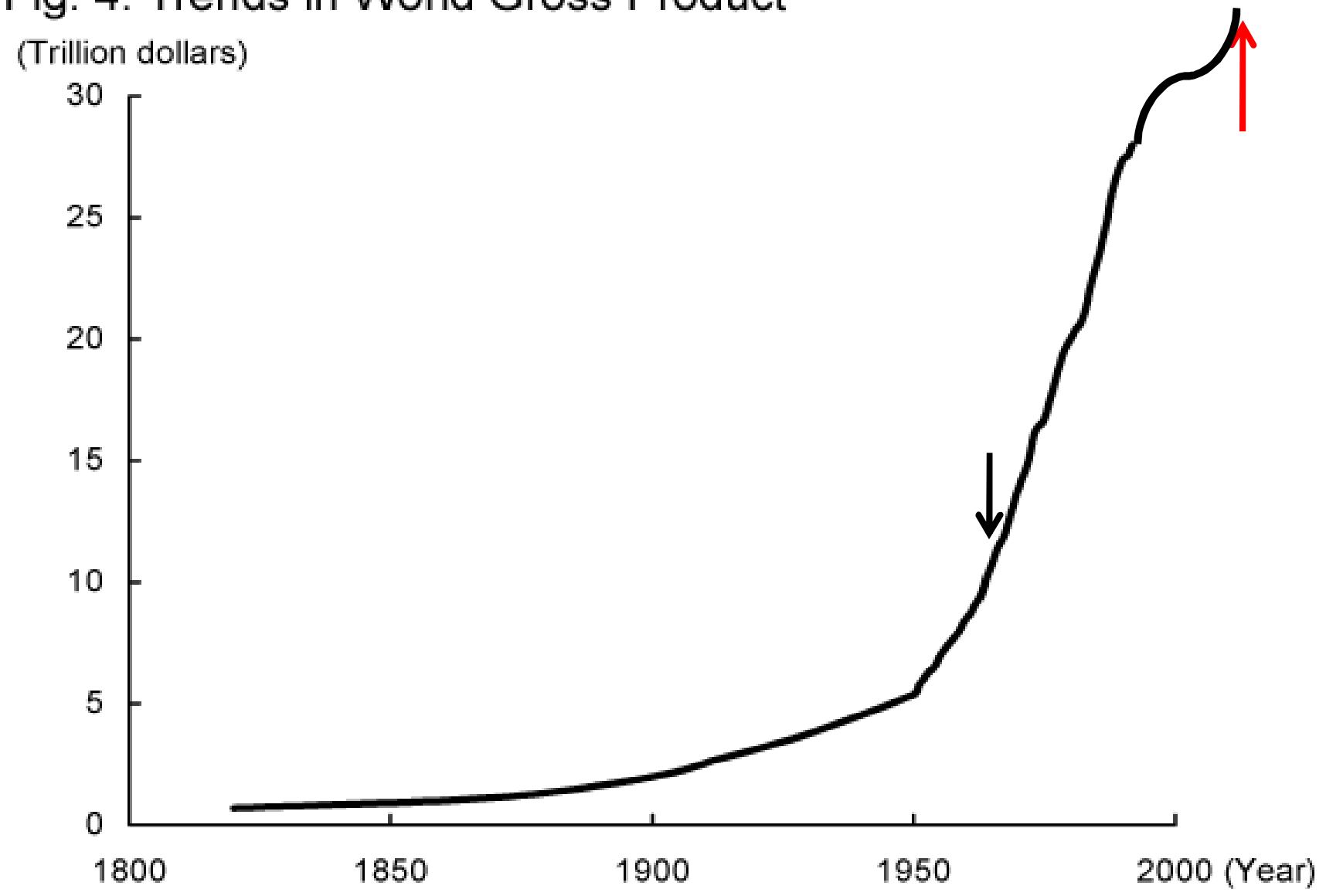
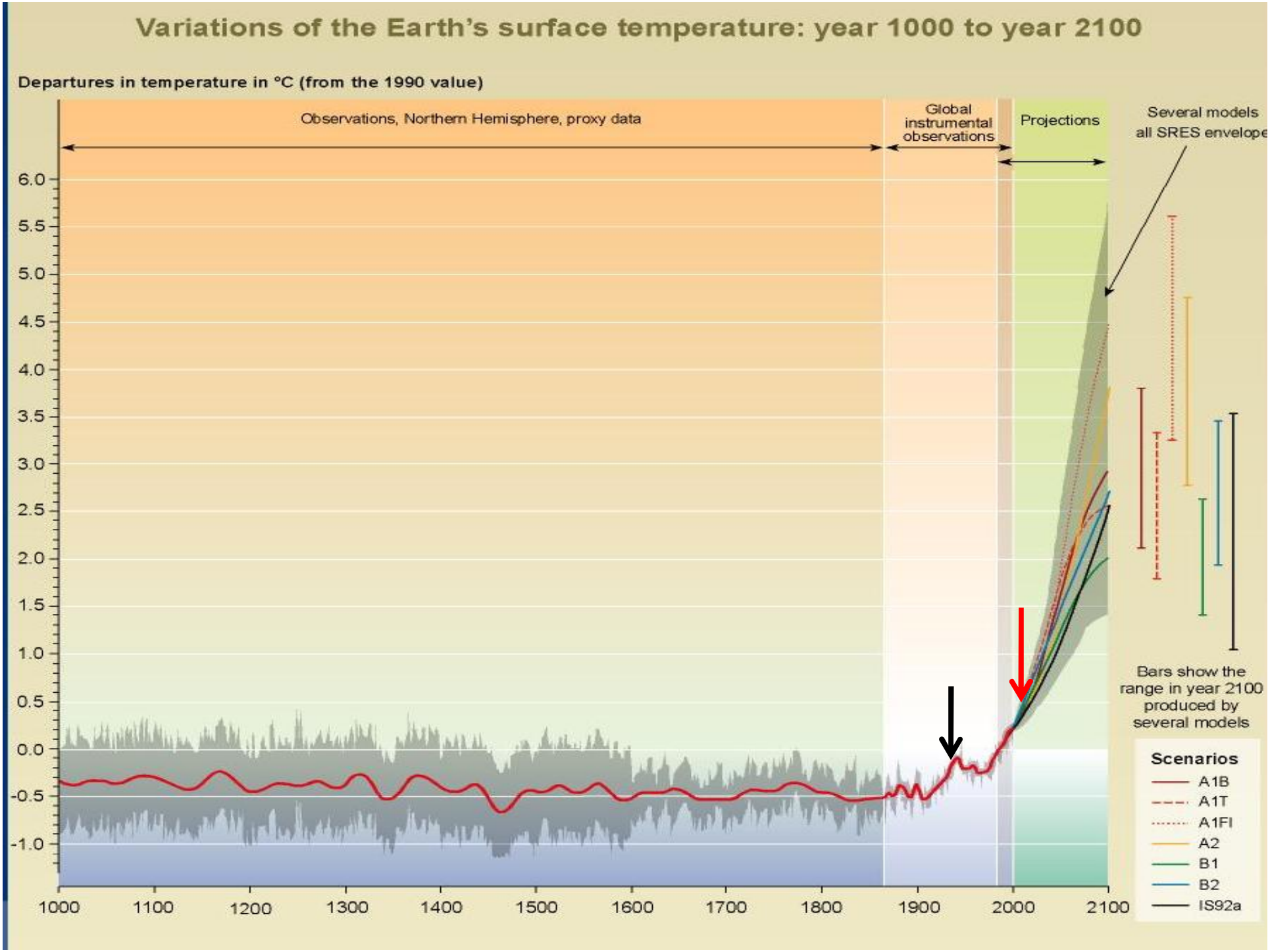

World population development
Billions
Billions
10
8
6
4
3
2
1
0
1750
1800
1850
1900
1950
2000
2050
Developing countries
Industrialized countries
UNEP
GRID
Arendal

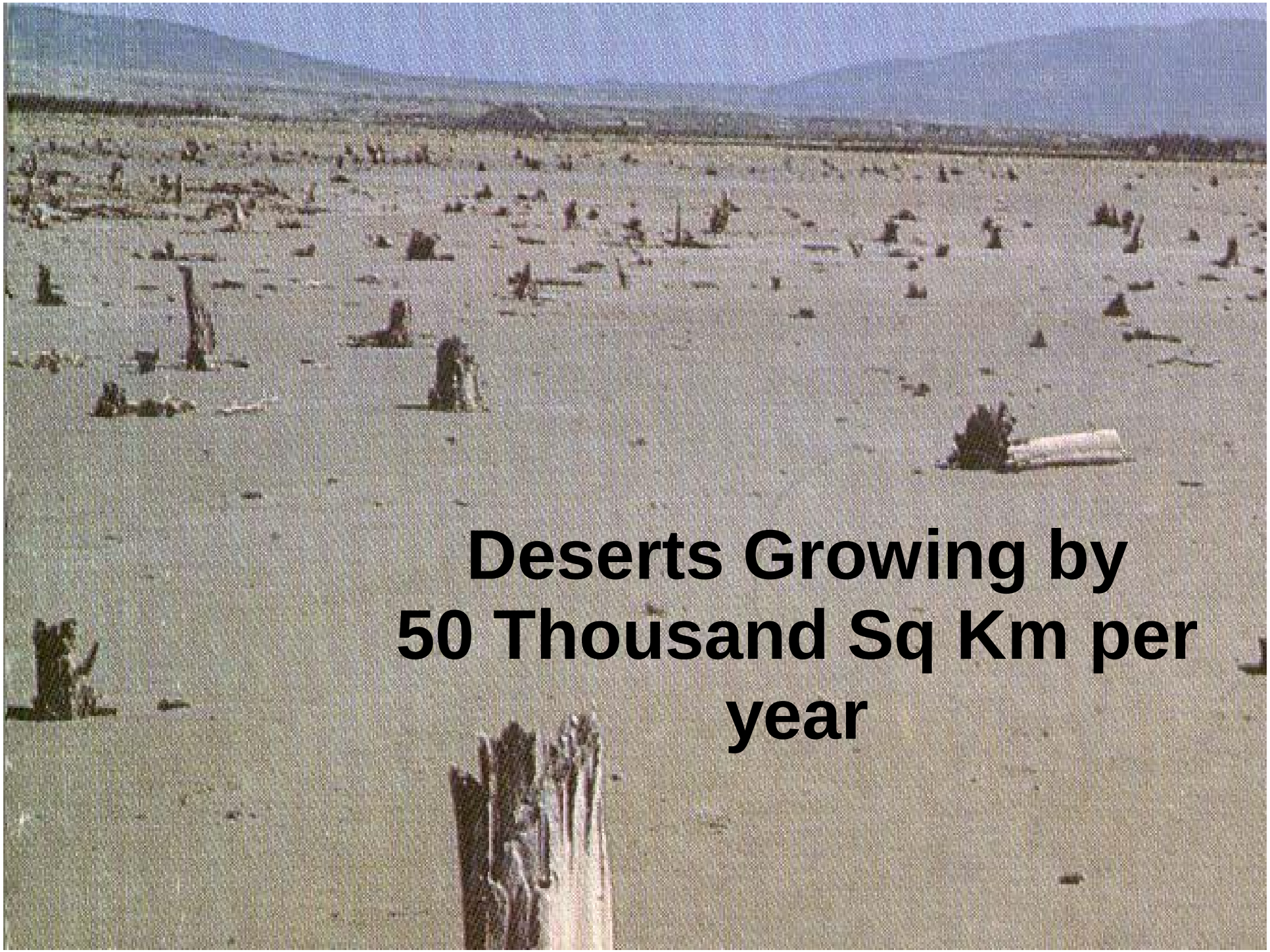
Fig. 4: Trends in World Gross Product



Note: Conversion into 1990 dollar equivalent using the GK (Geary-Khamis) method

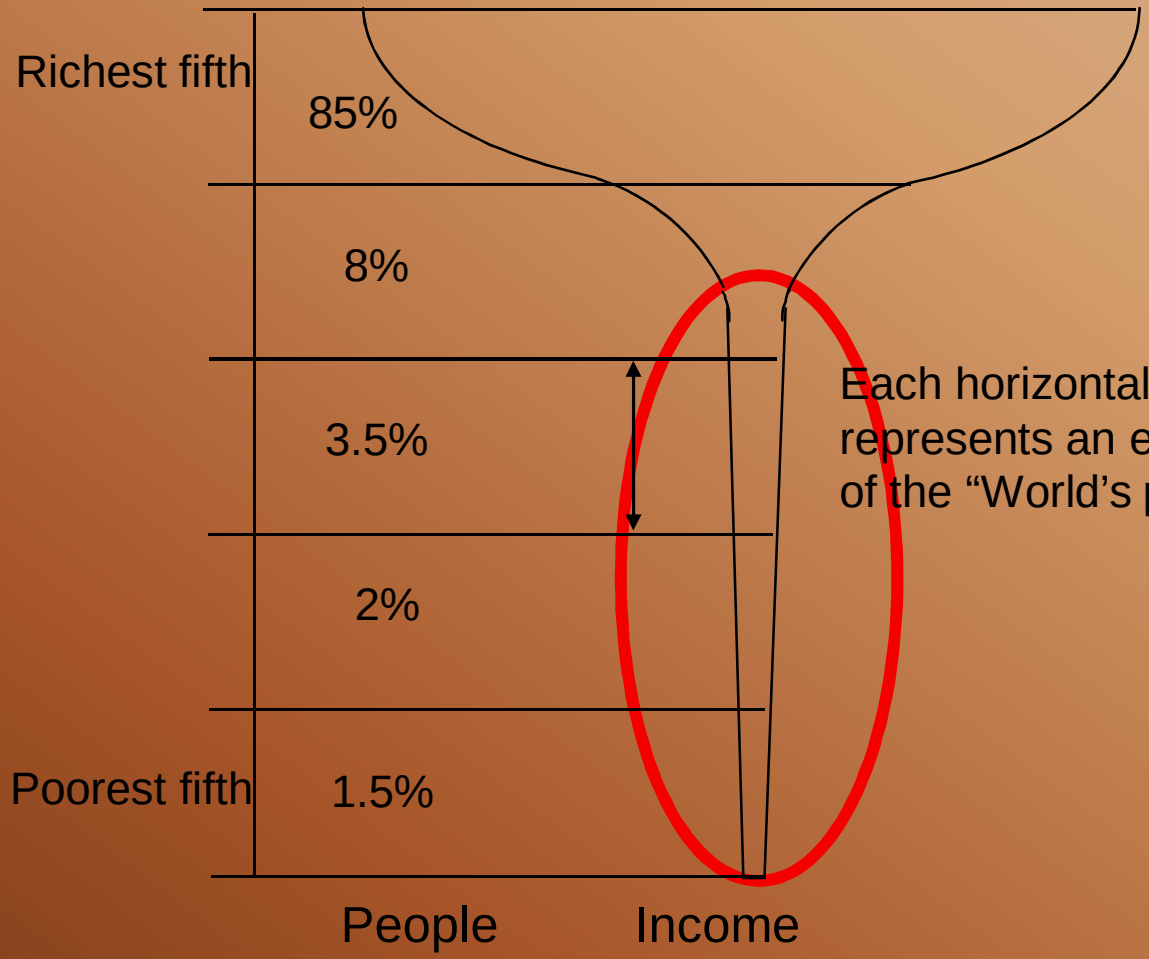
Source: Angus Maddison, "Monitoring the World Economy 1820-1992" (OECD, 1995)


Variations of the Earth's surface temperature: year 1000 to year 2100
Departures in temperature in °C (from the 1990 value)
Observations, Northern Hemisphere, proxy data
Global instrumental observations
Projections
Several models all SRES envelope
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
Bars show the range in year 2100 produced by several models
Scenarios
A1B
A1T
A1FI
A2
B1
B2
IS92a


Deserts Growing by
50 Thousand Sq Km per
year

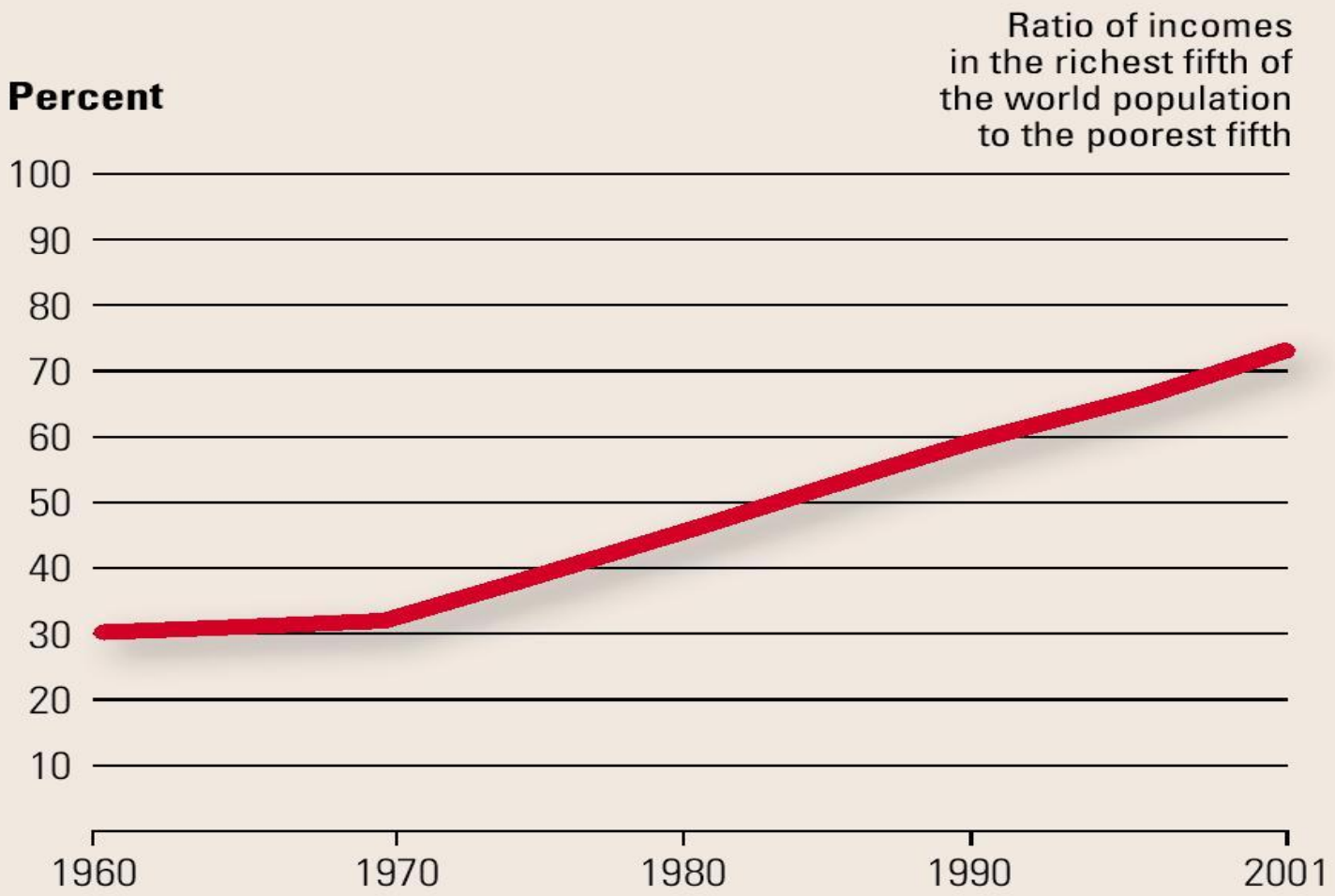

1780
1935
1956
1964
1971
2001
Gangotri Glacier
Scale (km)
0
0.5
1

Our Income Distribution



Development Alternatives

The Gap Is Widening



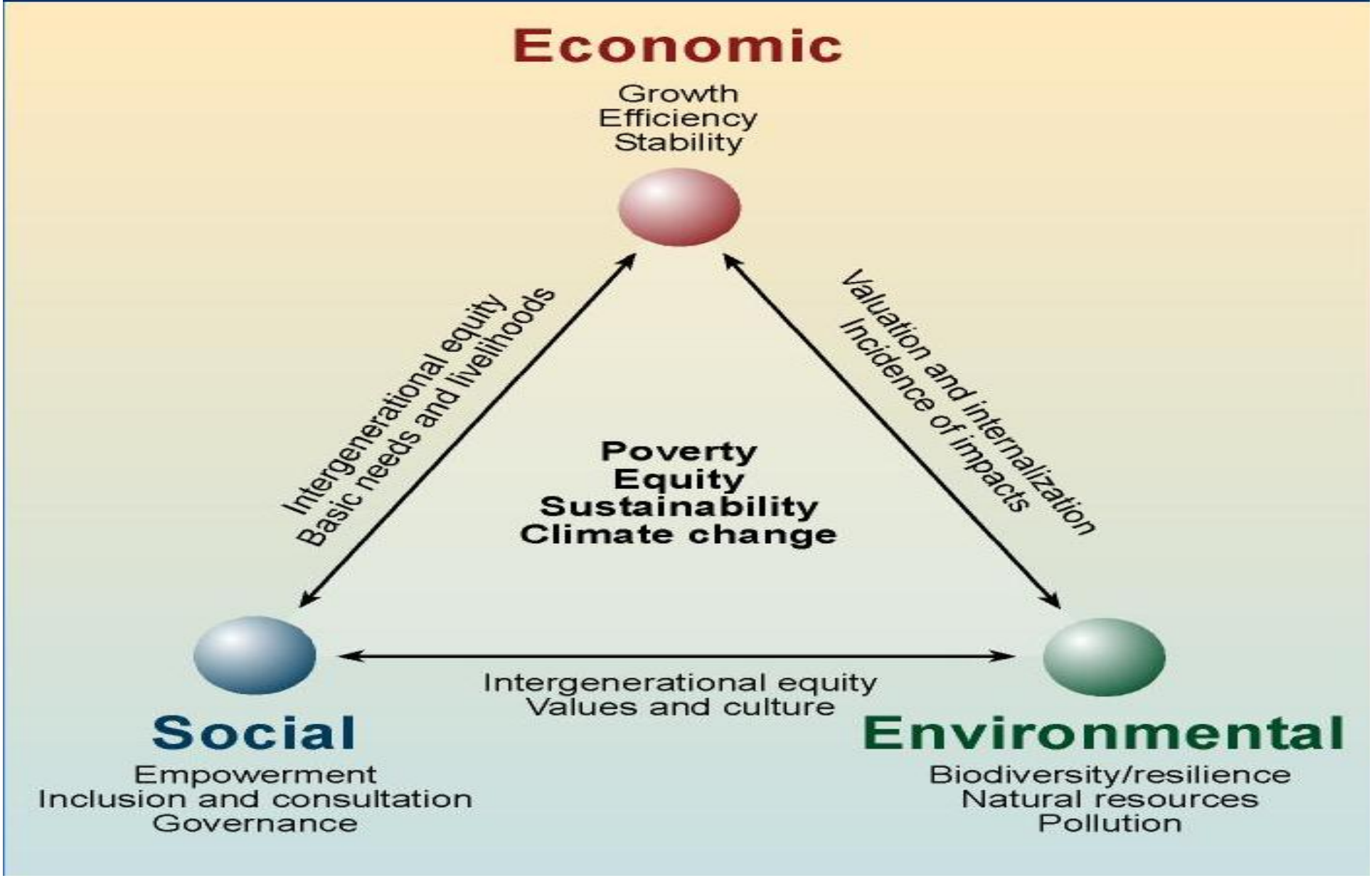
Source: UNDP 1998

Development Alternatives

Causes

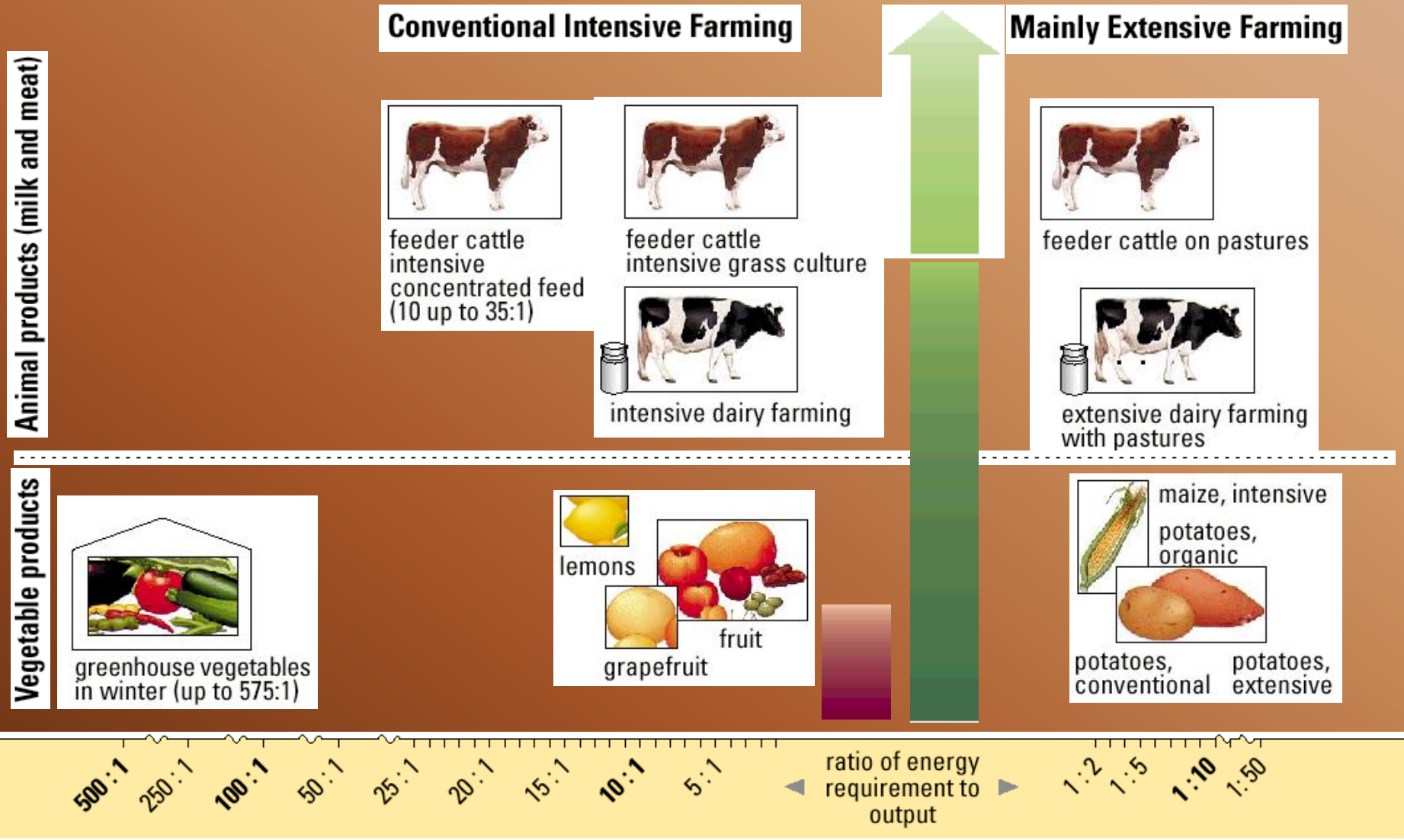
- Ø Consumption Patterns
- Ø Production Systems
- Ø Mindsets and Technologies
- Ø Short Time Horizons
- ØExpectations of High Financial Returns

Key elements of sustainable development and interconnections

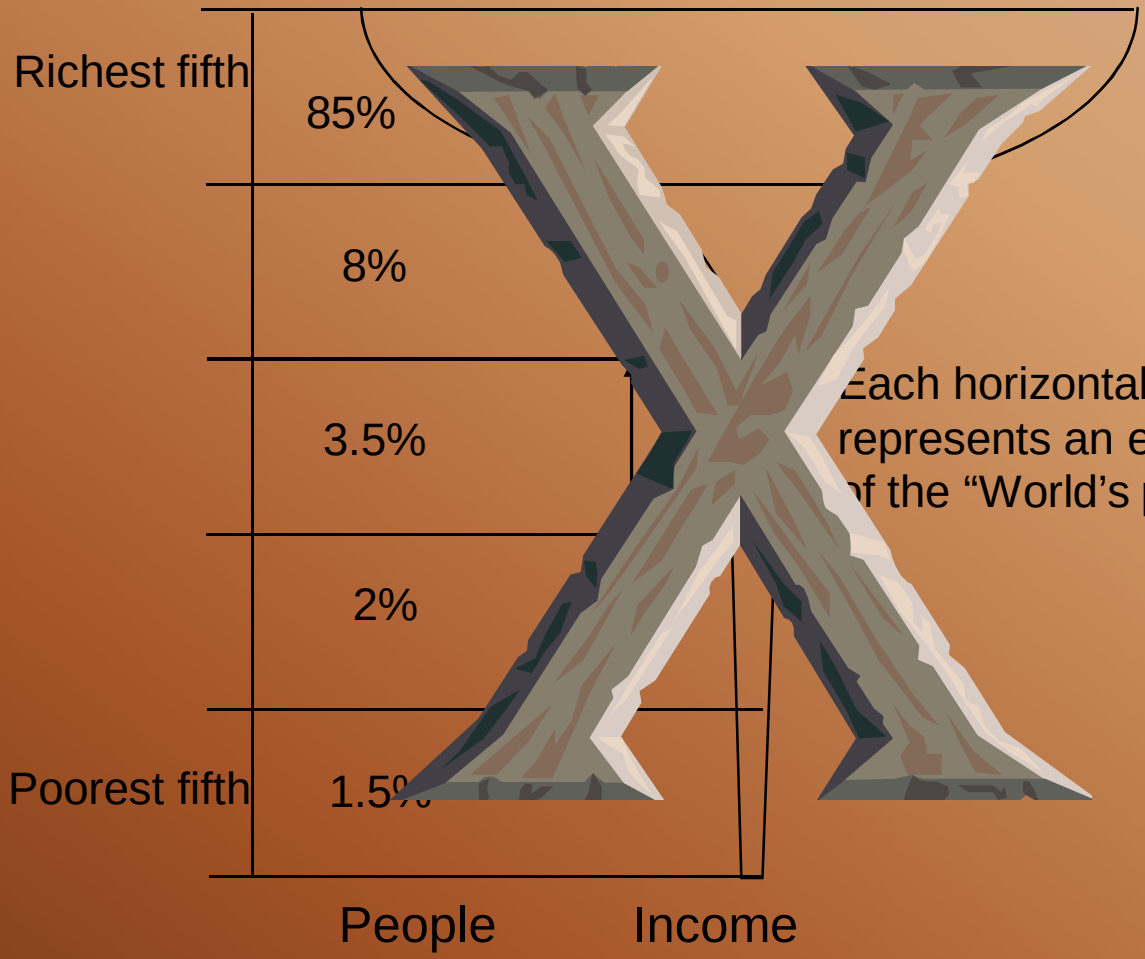


Energy Costs of Food – von Weizsaecker

High values correspond to low energy efficiency. For greenhouse vegetables in winter we expend over 500 calories of foreign energy for one calorie of food.

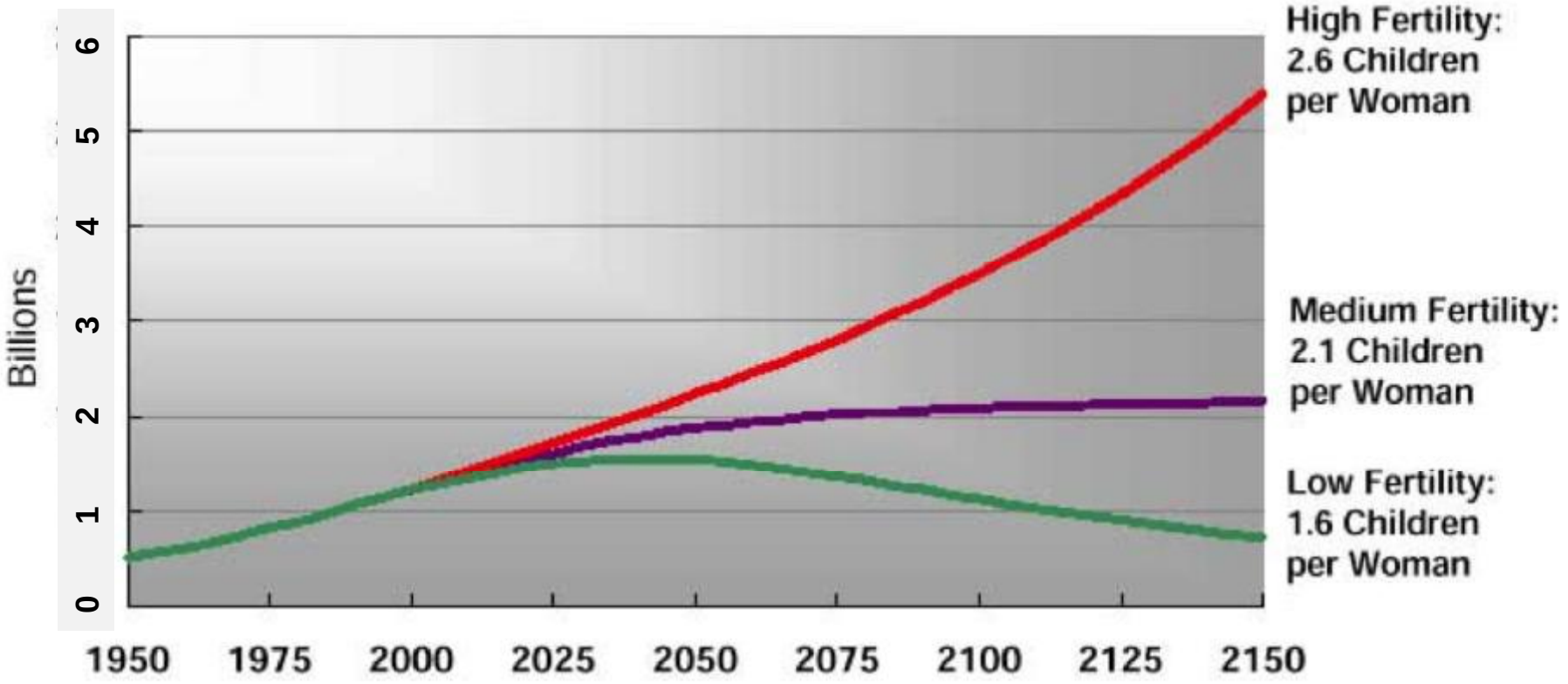


Our Income Distribution



Development Alternatives

Population Growth – The Three Scenarios



Source: UN, *World Population Projections to 2150*, 1998.

The First World

Some 2 Billion People Mining the Landscape of its Treasures, Productive Capacity and Health

Development Alternatives

The Fundamental Choices: North

BAU ?

or

Fine-Tuning ?

or

Systemic Change ?

The Third World

Some 3 to 4 Billion People Surviving on a Landscape of Poverty, Inequity, Vulnerability and Environmental Degradation

Development Alternatives

The Fundamental Choices: South

to Copy-cat?

or

to Piggy-back ?

or

to Leap-frog?

The Pursuit of Global Competitiveness

Automatically Promotes Copy-Cat Strategies

Development Alternatives


MGF
M
THE METROPOLITAN
ALL-NEW
ESTEEM
MGF
Get the
Lion's Protection

Development Alternatives

Projected Premature Annual Deaths due to Urban Air Pollution, Total and by Economic Group or Region, 2001–2020

Region	Premature Deaths (thousand per year)
Established market economies	20
Former socialist economies	200
China	590
India	460
East Asia and the Pacific	150
Latin America and the Caribbean	130
South Asia	120
Middle East Crescent	90
Sub-Saharan Africa	60
World	1,810

Source: World Bank.

Development Alternatives

Efficiency in Agriculture

Big Engineering Works

Development Alternatives


M16

Mining the Earth

High Pressure on the Environment

Choice and Production of Food on Ecological Costs

High values correspond to low energy efficiency. For greenhouse vegetables in winter we expend over 500 calories of foreign energy for one calorie of food.

Conventional Intensive Farming

Mainly Extensive Farming

Animal products (milk and meat)

feeder cattle intensive concentrated feed (10 up to 35:1)

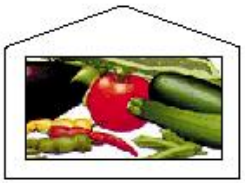
feeder cattle intensive grass culture

intensive dairy farming

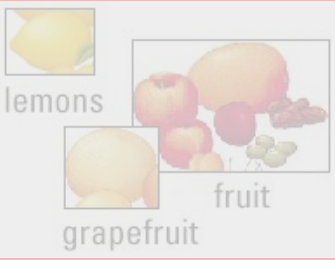
feeder cattle on pastures

extensive dairy farming with pastures

Vegetable products



greenhouse vegetables in winter (up to 575:1)



lemons

fruit

grapefruit

maize, intensive

potatoes, organic

potatoes, conventional

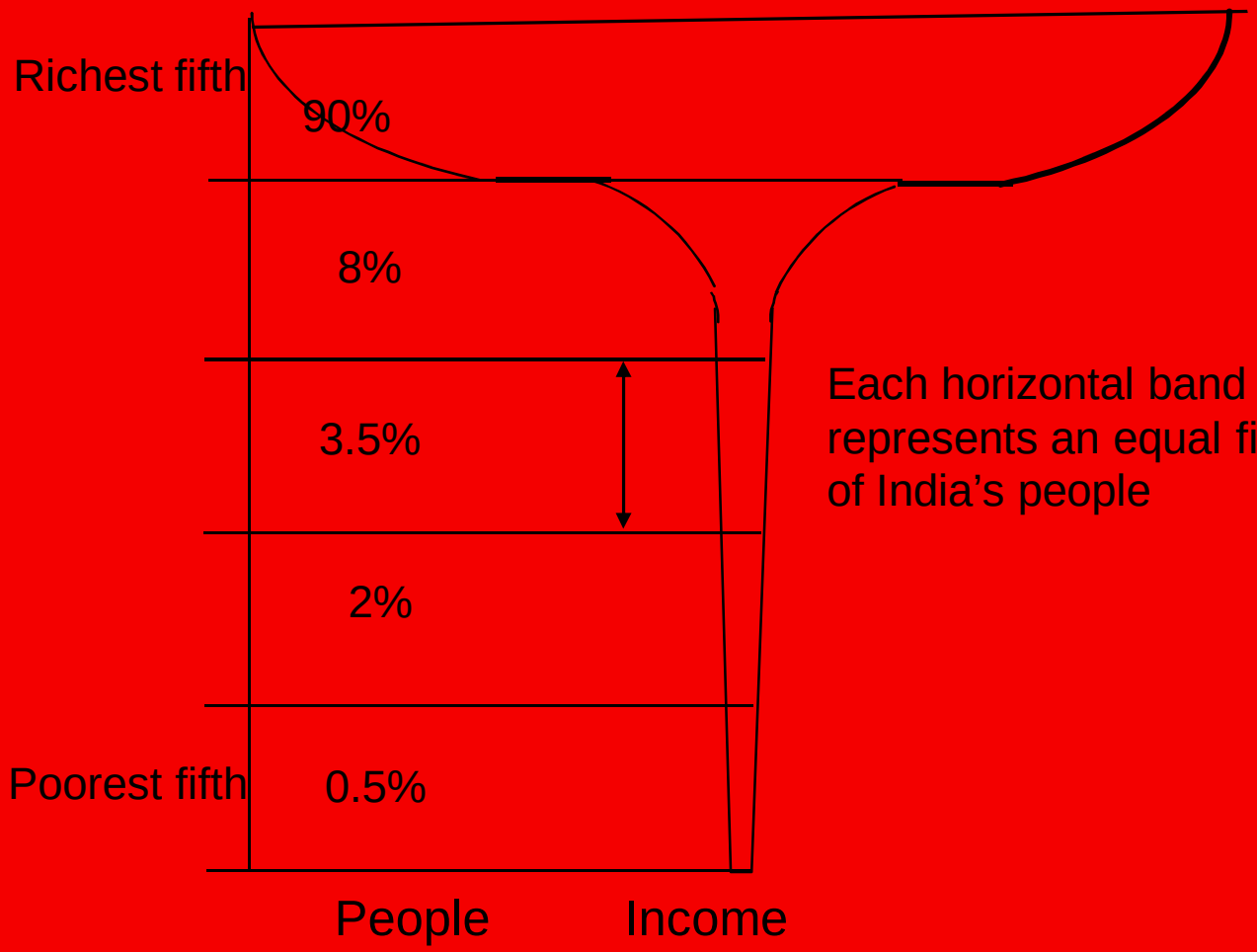
potatoes, extensive

500 : 1 | 250 : 1 | 100 : 1 | 50 : 1 | 25 : 1 | 20 : 1 | 15 : 1 | 10 : 1 | 5 : 1

ratio of energy requirement to output

1 : 2 | 1 : 5 | 1 : 10 | 1 : 50

Resulting Income Distribution



The Copy-Cat Outcomes

- Increased Income Disparities
- Massive Degradation of Environment
- Large Footprint, External Dependence
- Loss of Cultural and Social Capital
- More Exclusion, Alienation, Violence
- Overshoot and Collapse

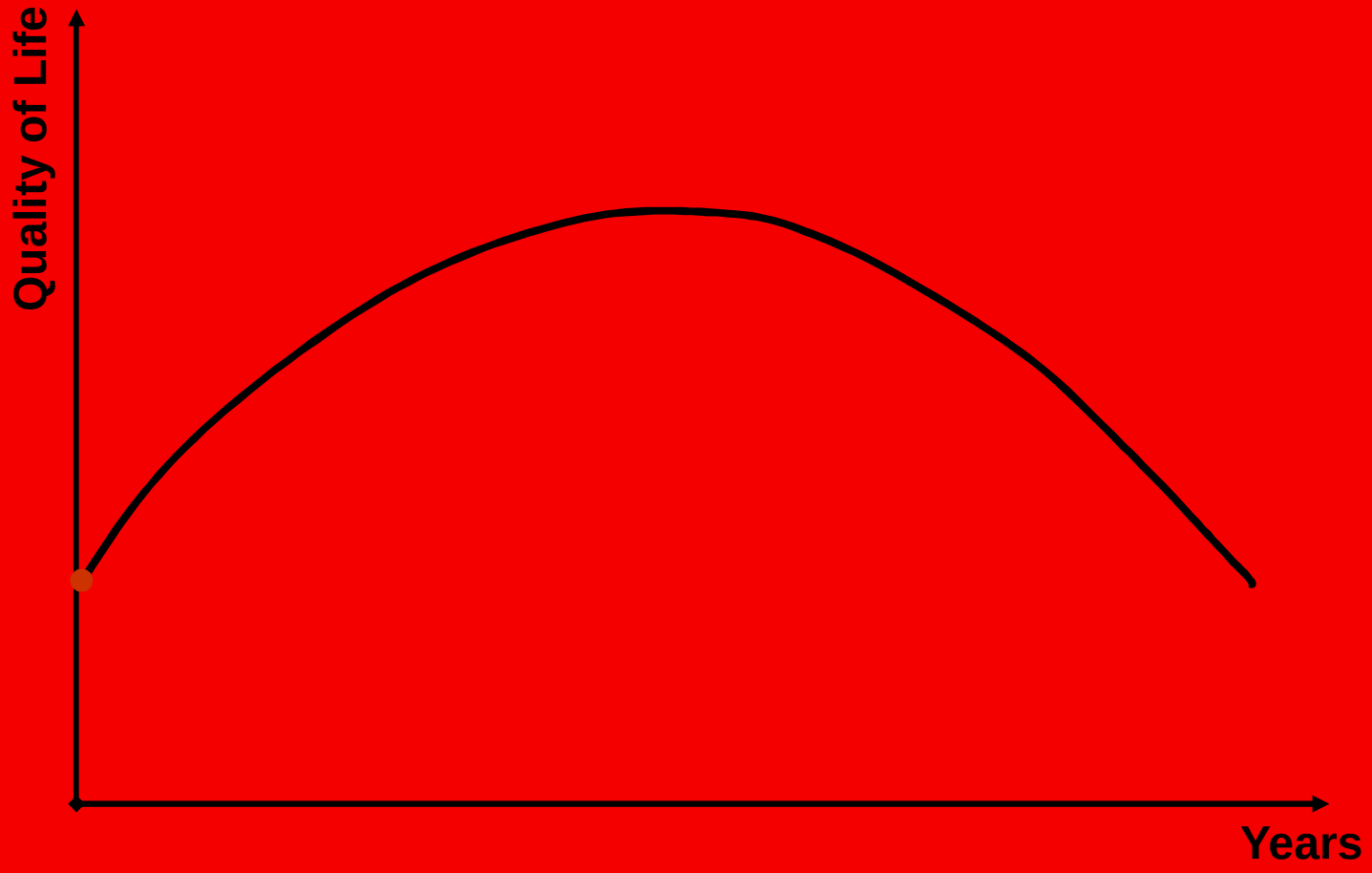
Footprint

Bio-Capacity

The Ecological Footprint of a Highly Industrial Economy

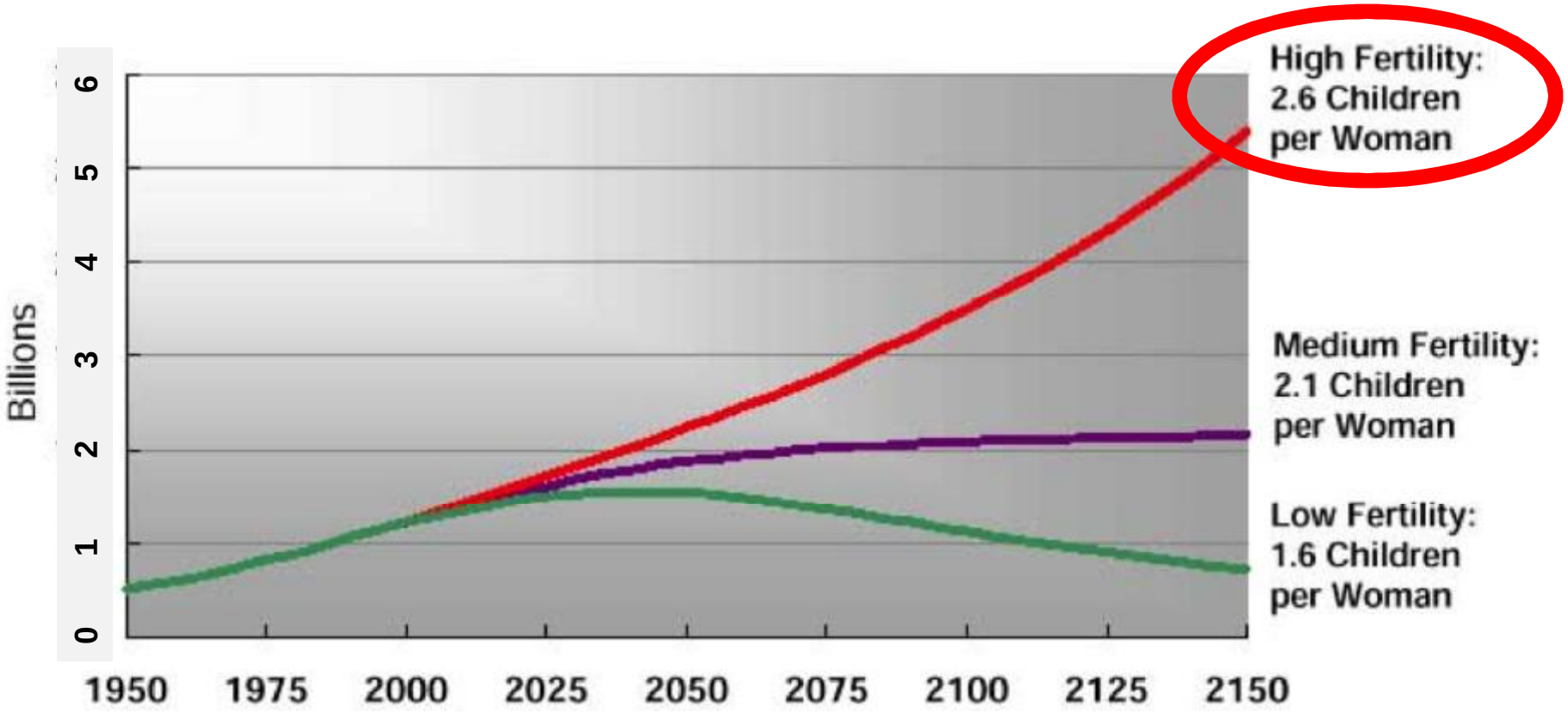
Development Alternatives

The Likely Results of a Copy-Cat Approach



Development Alternatives

Population Growth – The Three Scenarios



Source: UN, *World Population Projections to 2150*, 1998.

The Pursuit of Creating National Wealth

Largely Needs

Piggy-Back Strategies

Development Alternatives

Factor 4

Potential Efficiency

- **Technical HK or FT**
- **Mainly Energy Saving**
- **Fiscal Incentives**
- **Basic Caring**

Development Alternatives

Factor 4 – von Weizsaecker

Automobiles

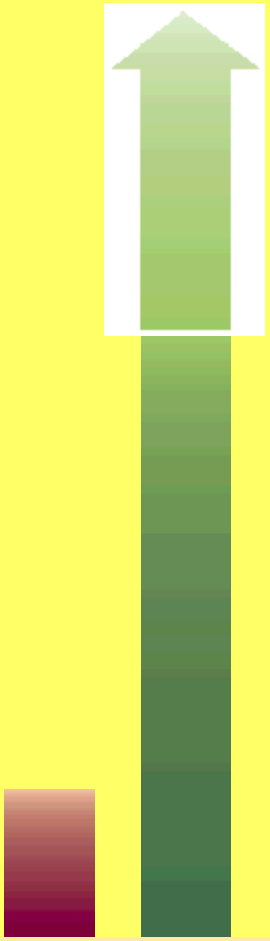
Hypercar

Today

Tomorrow

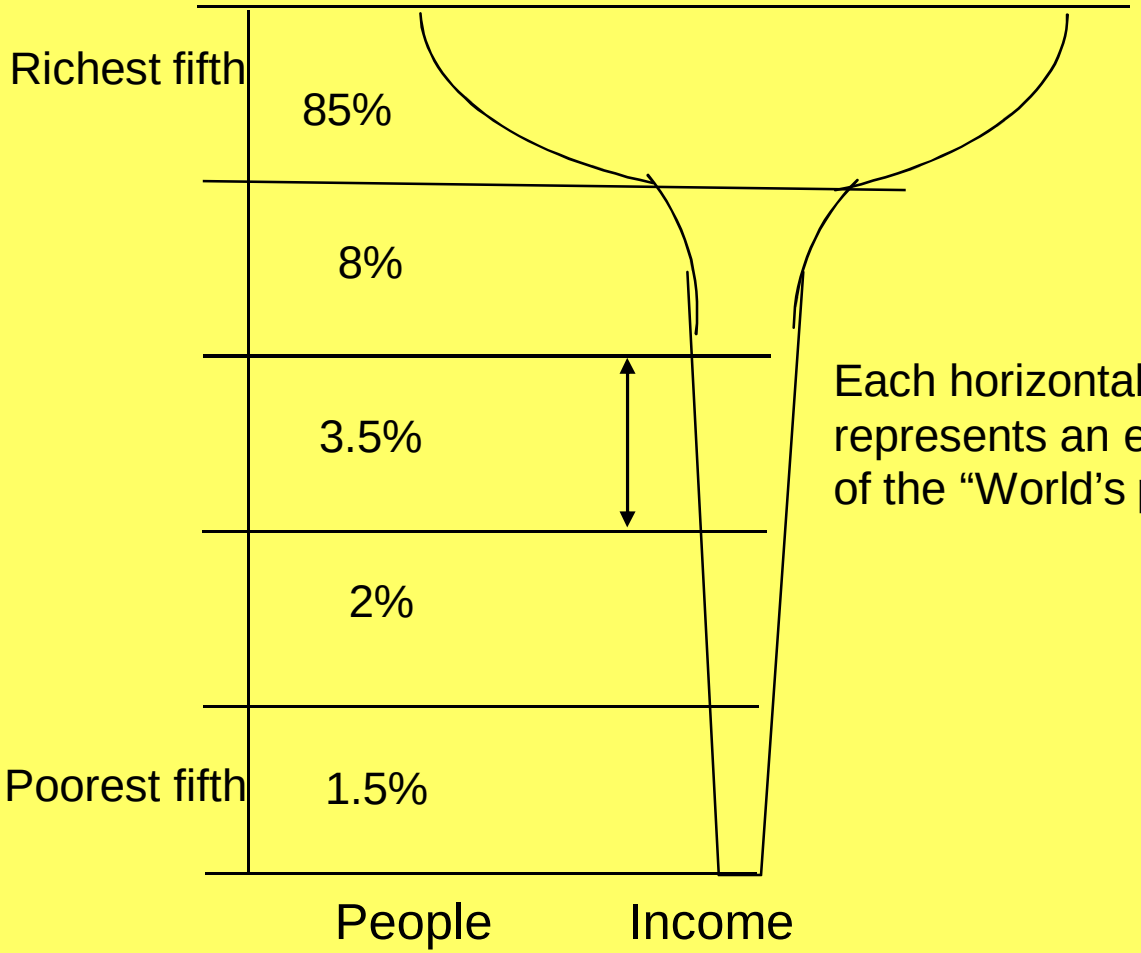
Energy and Material Efficiency

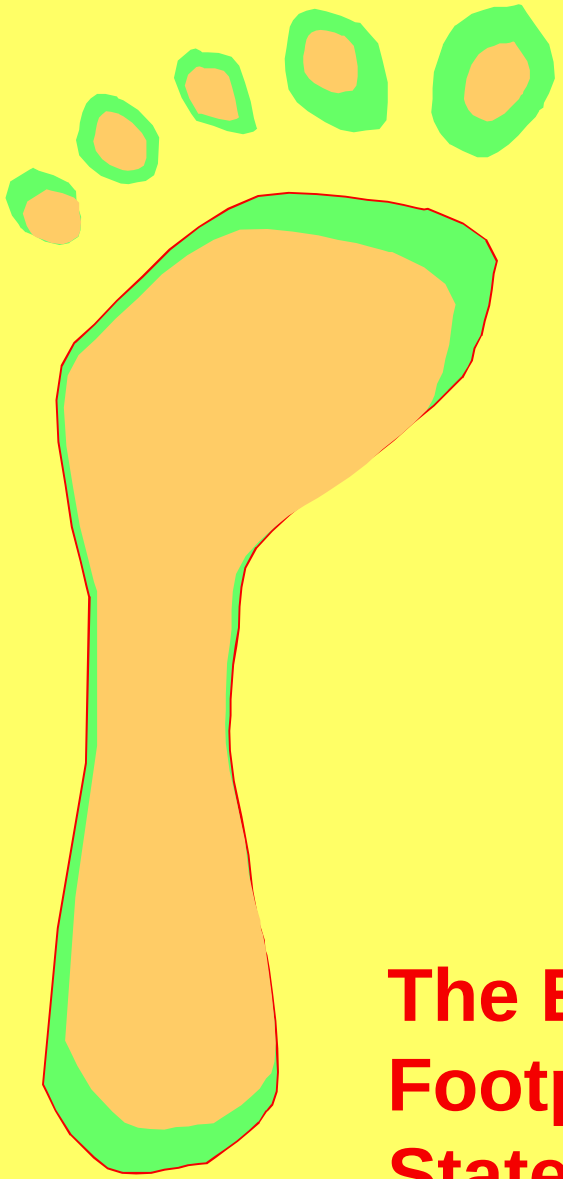
Light Bulbs



Energy Efficiency

Resulting Income Distribution





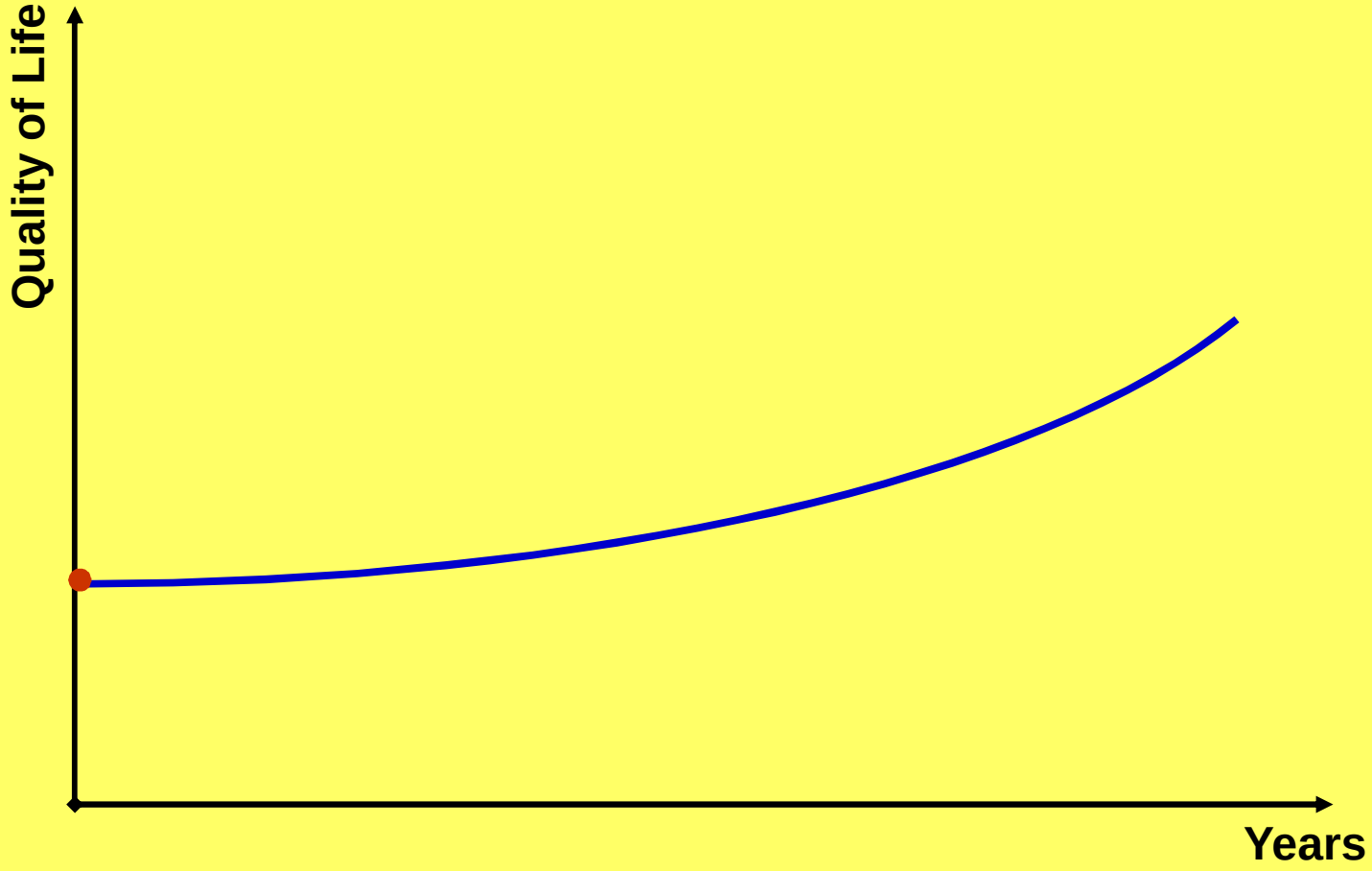
Footprint

Bio-Capacity

The Ecological Footprint of a Steady State Economy

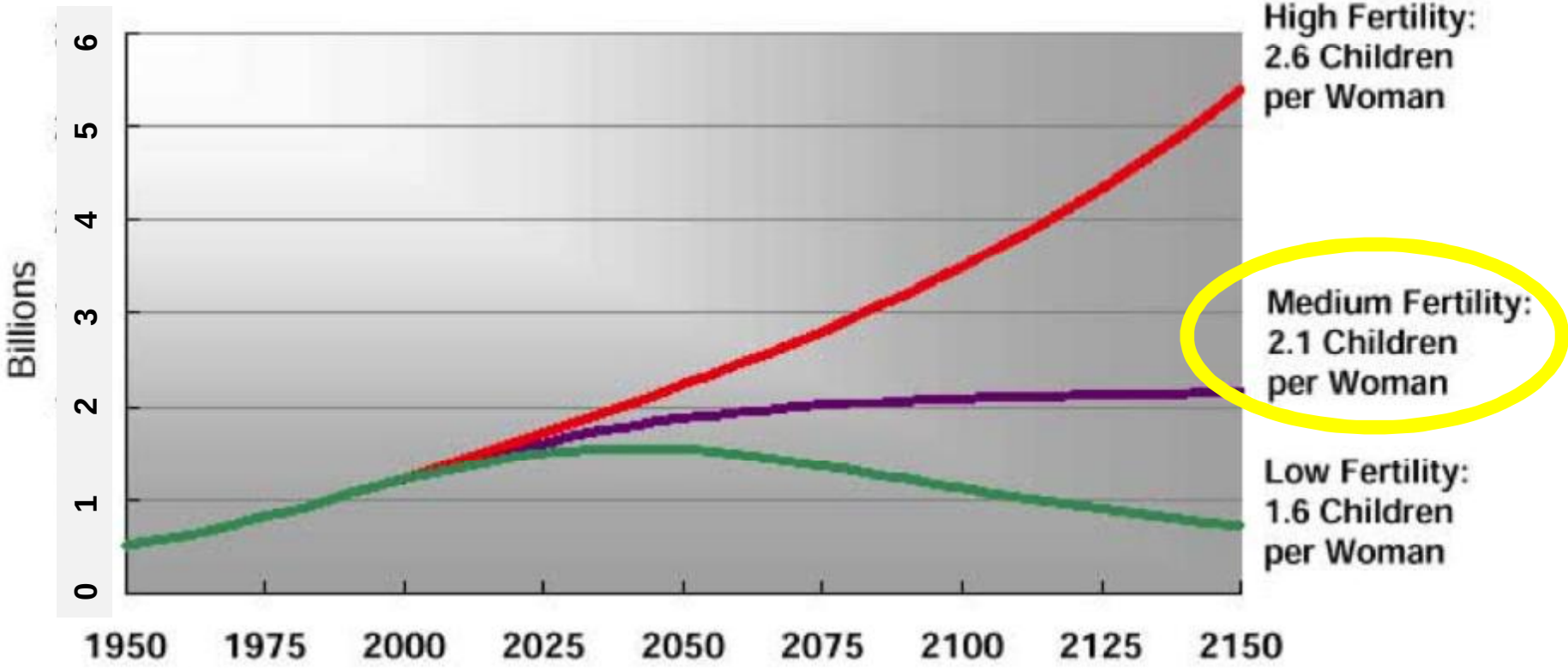
Development Alternatives

Likely Results of a Piggy-Back Approach



Development Alternatives

Population Growth – The Three Scenarios



Source: UN, *World Population Projections to 2150*, 1998.

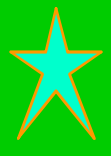
The Pursuit of Gross National Happiness

Necessarily Depends On Leap-Frog Strategies

Development Alternatives

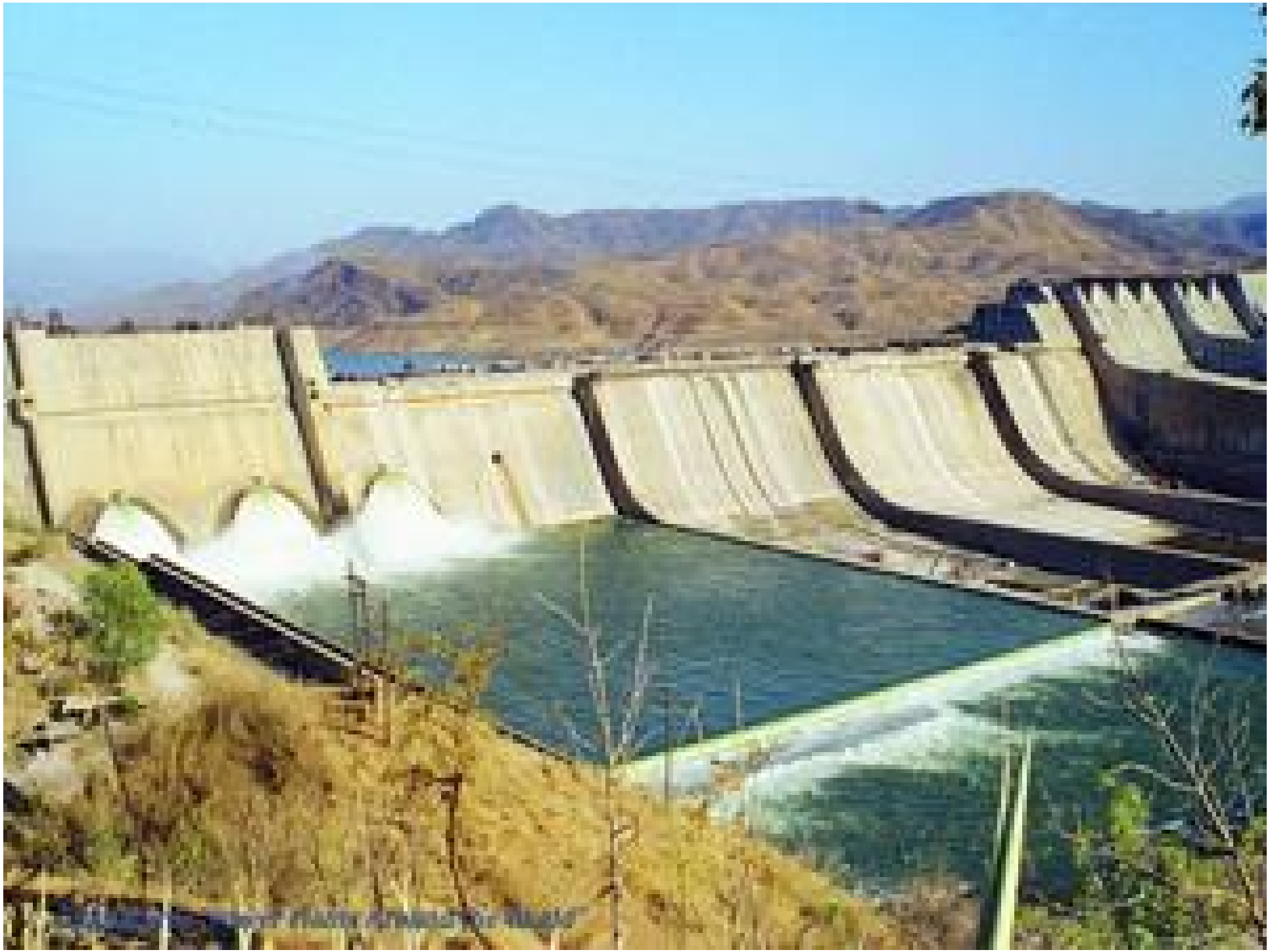
Latent Productivity

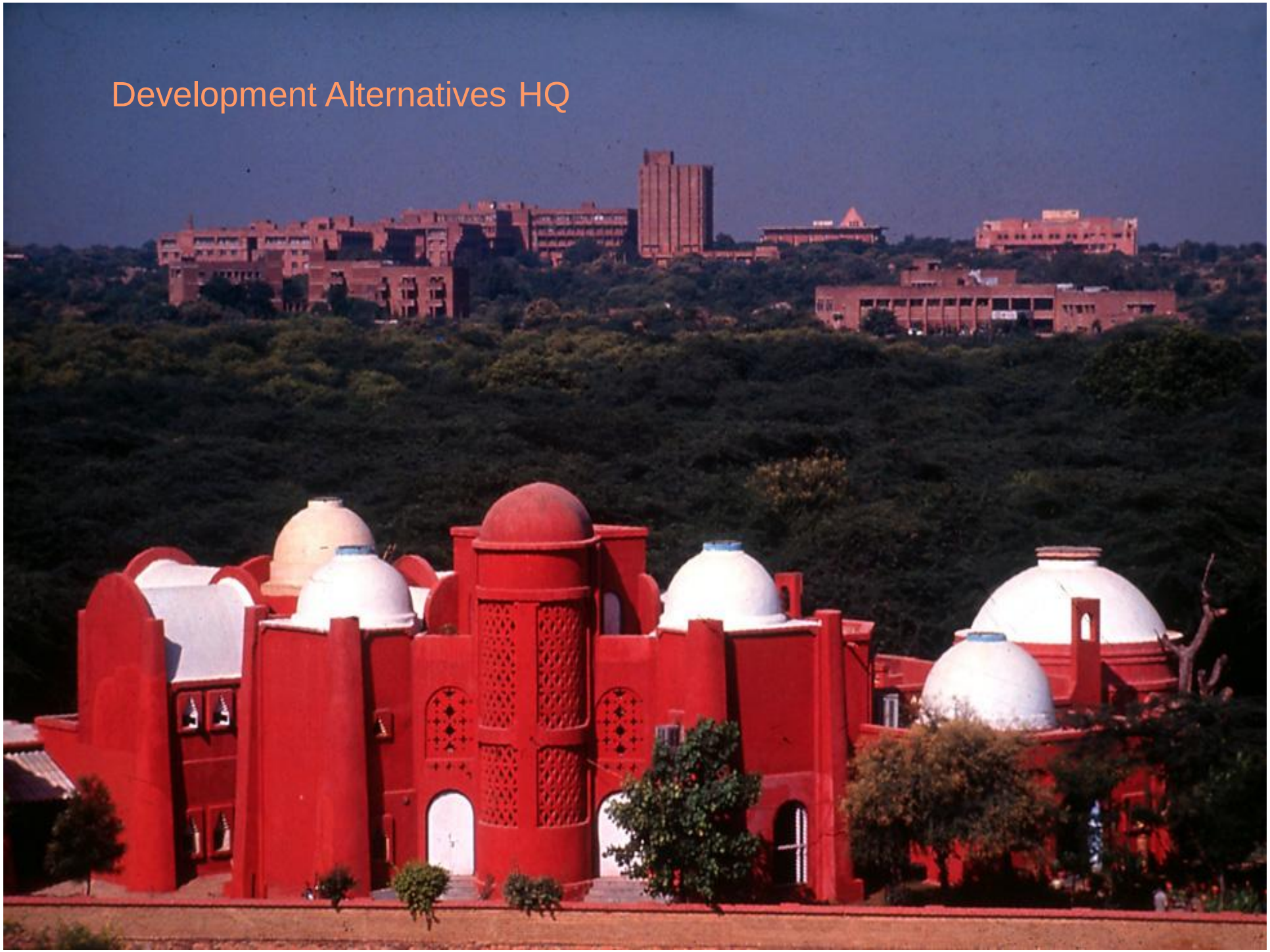
Clean Technologies
Mainly Material Saving
Innovation Incentives
Wide Awareness
Regulation



Development Alternatives


VESTAS



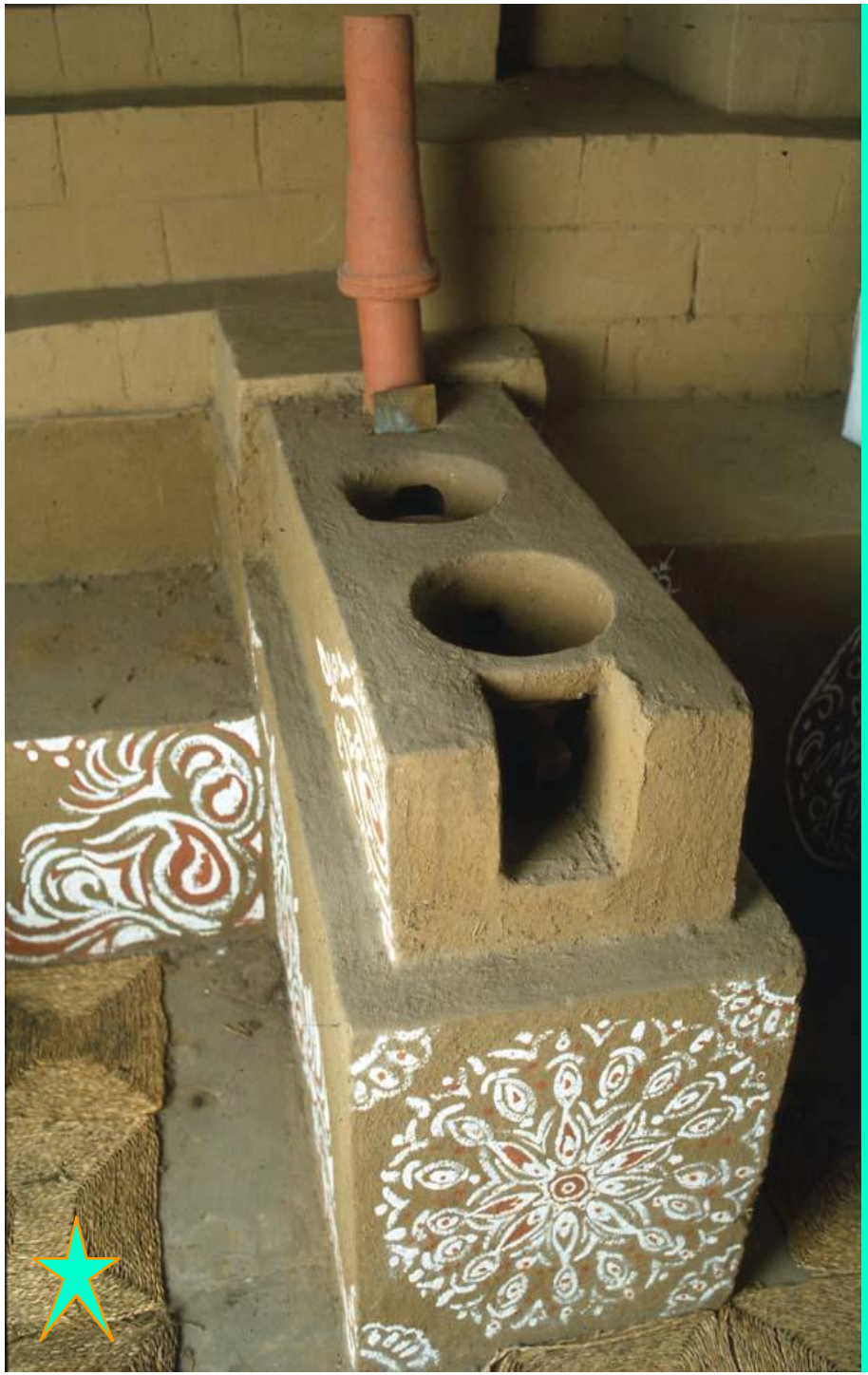

Development Alternatives HQ

Designed for Carbon Neutrality

- Ø Zero CFCs
- Ø Low Carbon Emissions
- Ø No Pollution

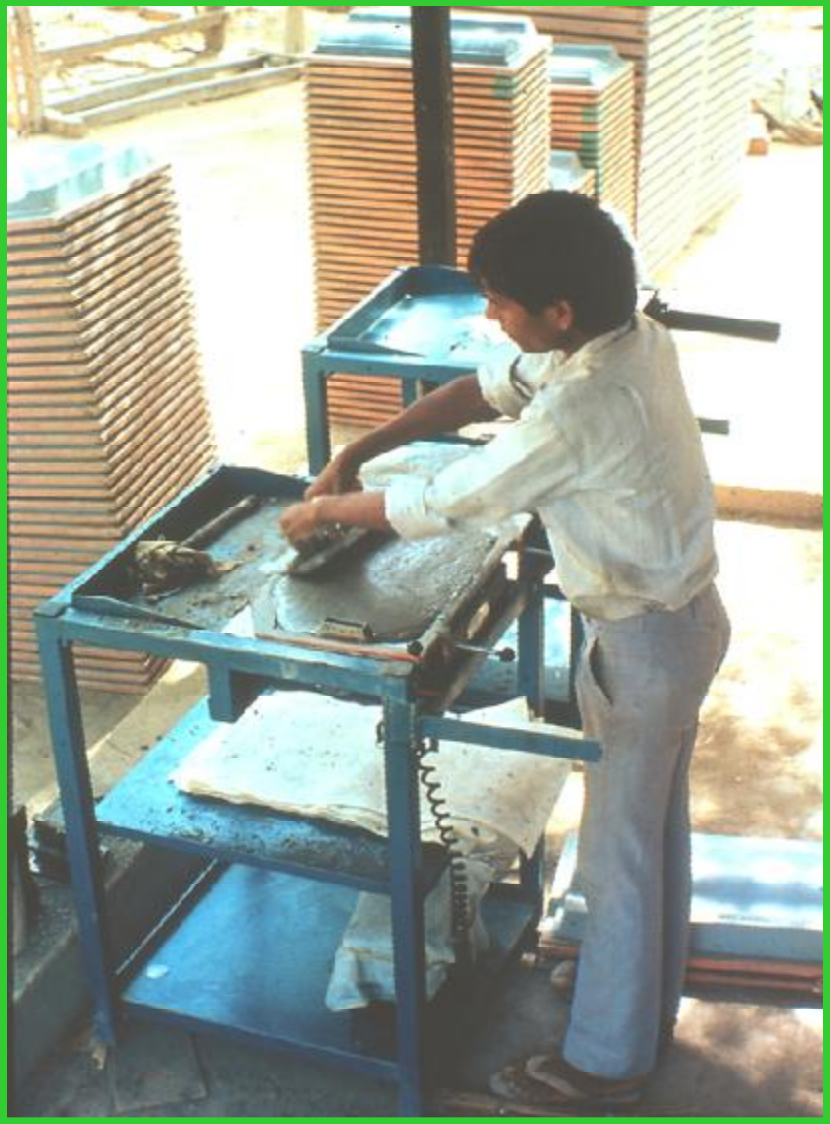
Development Alternatives

TARA WOODSTOVES



Development Alternatives

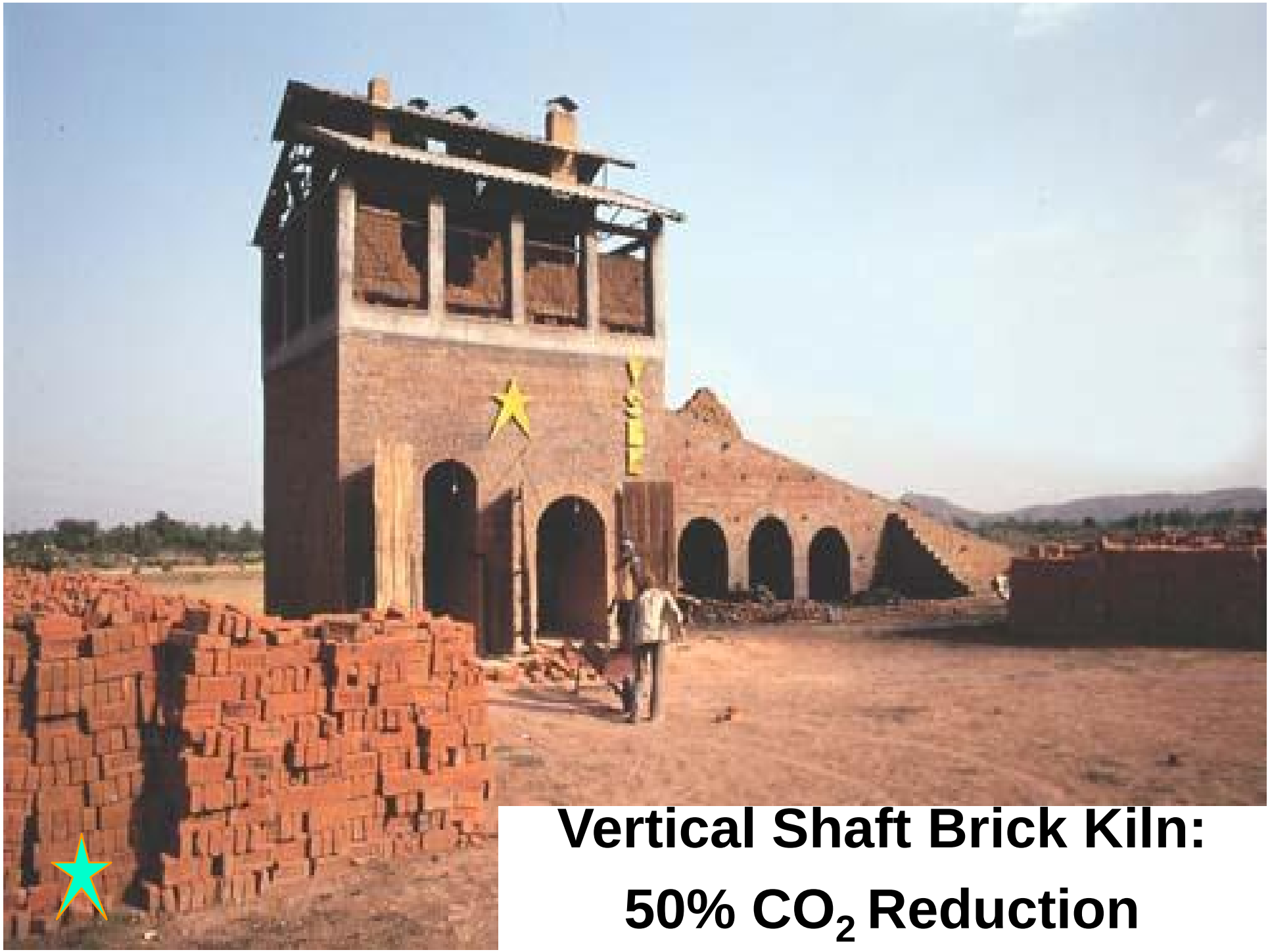
Development Alternatives



Development Alternatives


Rs 250 per Sq Ft

Development Alternatives

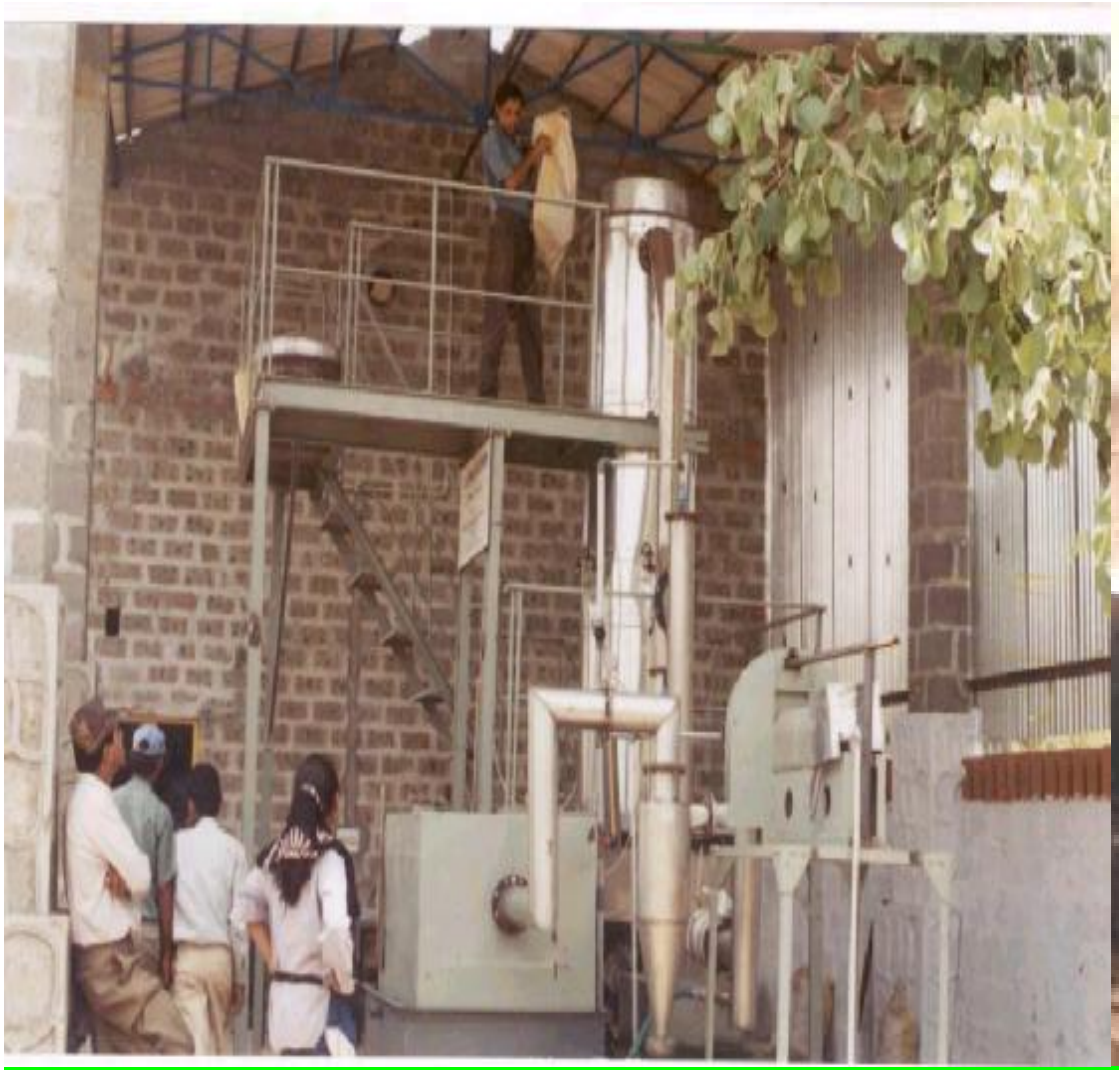


Vertical Shaft Brick Kiln:

50% CO_2 Reduction

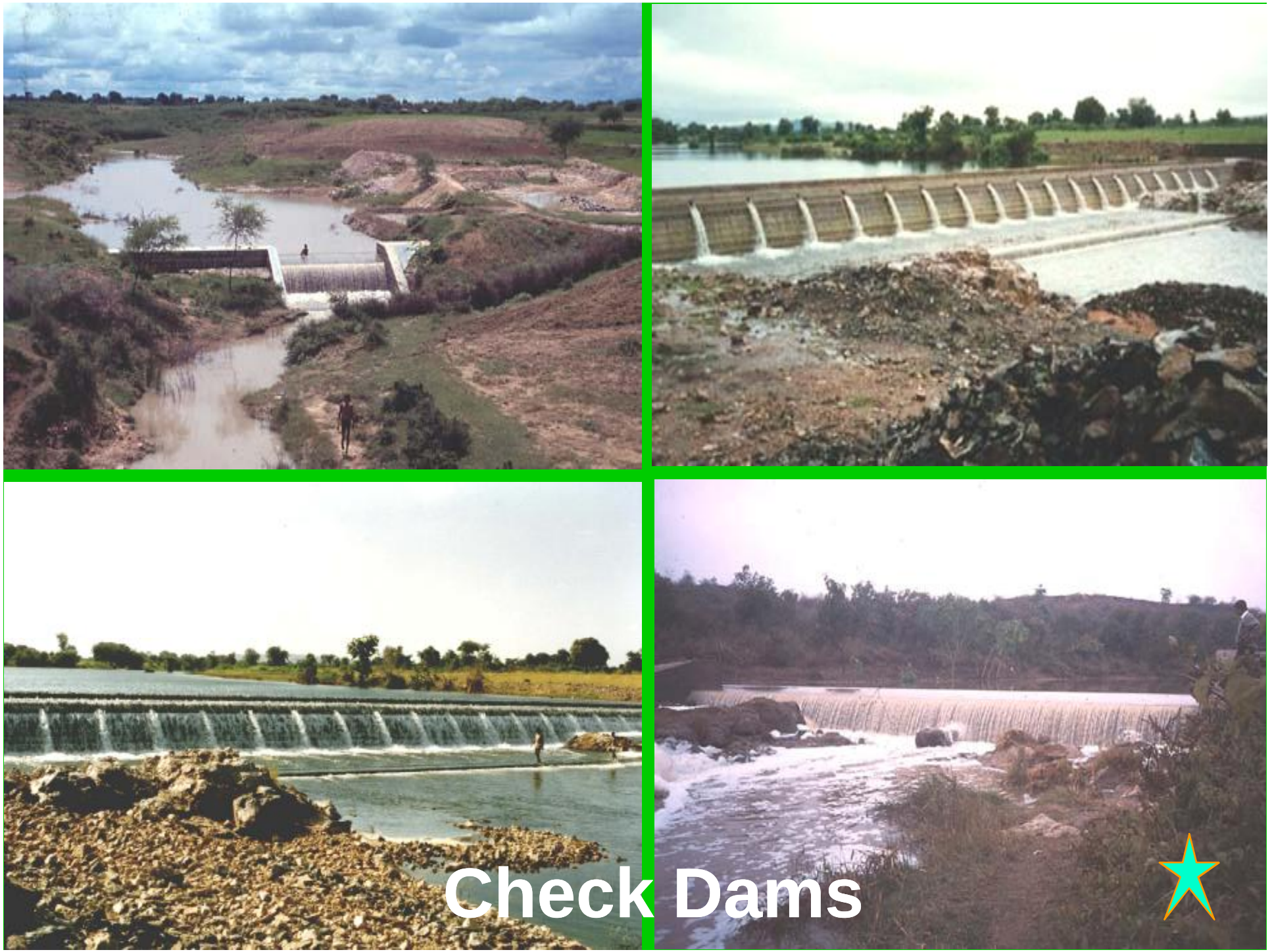
Development Alternatives

Development Alternatives



Development Alternatives

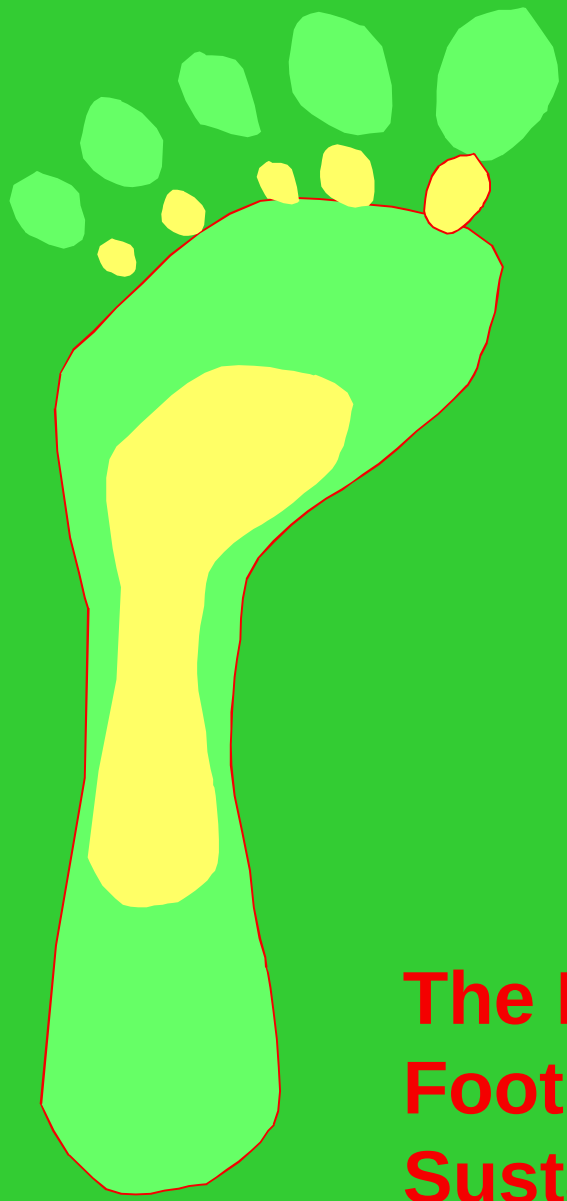
DESI Power


Check Dams

Sustainable Distribution of Global Income

Each horizontal band represents an equal fifth of the world's people

Development Alternatives



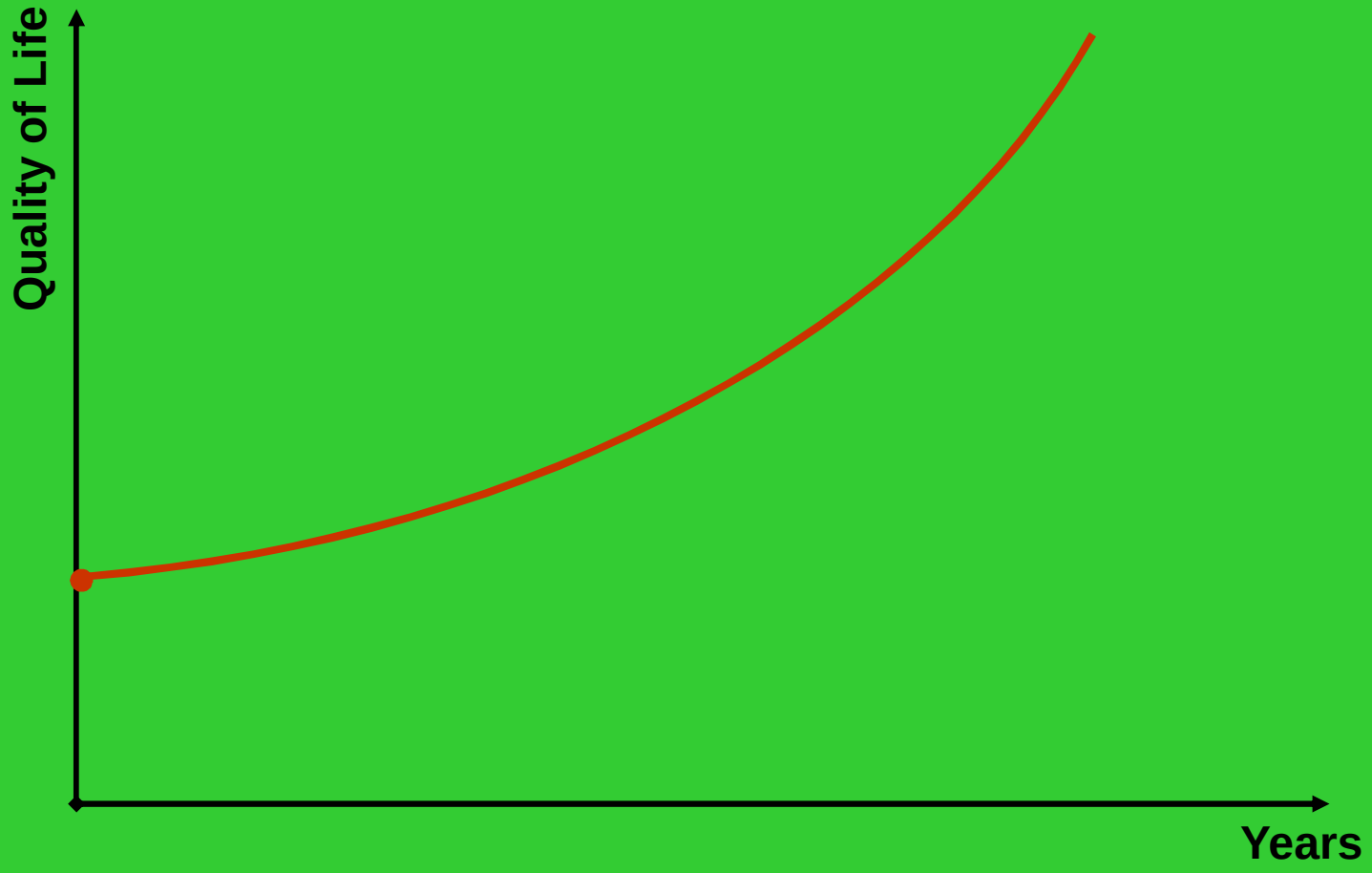
Footprint

Bio-Capacity

The Ecological Footprint of a Sustainable Economy

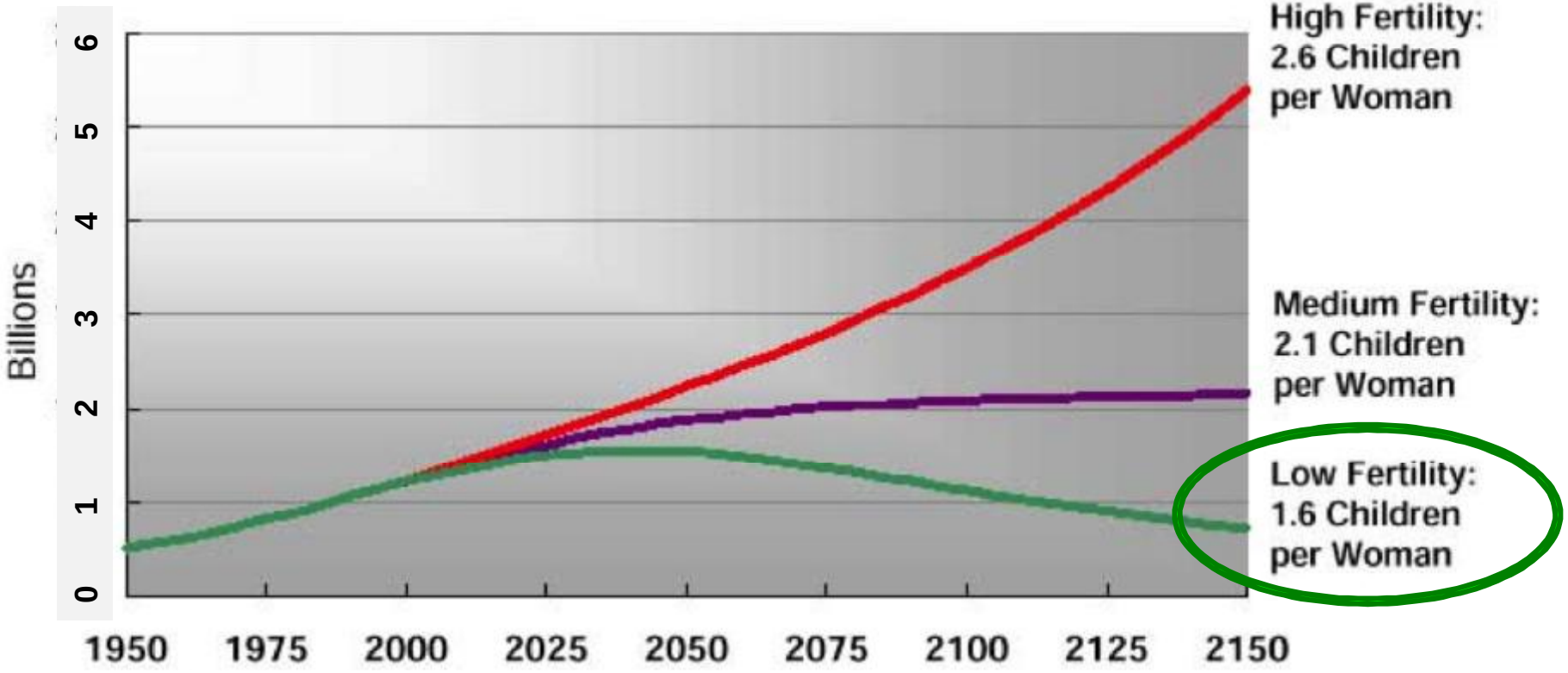
Development Alternatives

Expected Results of a Leap-Frog Approach



Development Alternatives

Population of India – The Three Scenarios



Source: UN, *World Population Projections to 2150*, 1998.

The Next Wave: Factor 50

Systemic Impact

Breakthrough Technologies

Zero Emission

Demand Side Management

Catastrophe Driven

Development Alternatives

After Factor 10:
Horse Jump ?

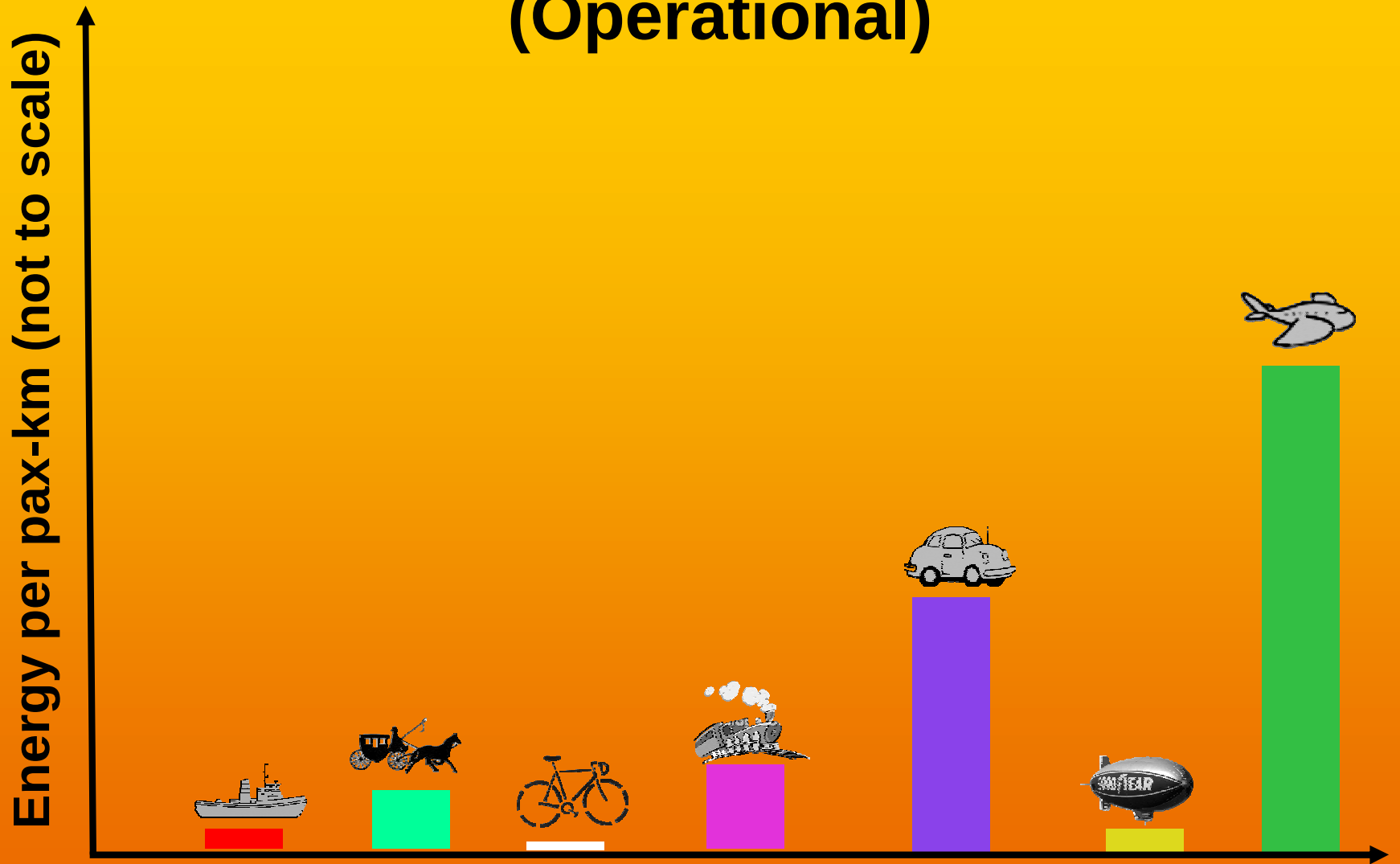
DISRUPTIVE TECHNOLOGY

Development Alternatives

Transport Systems

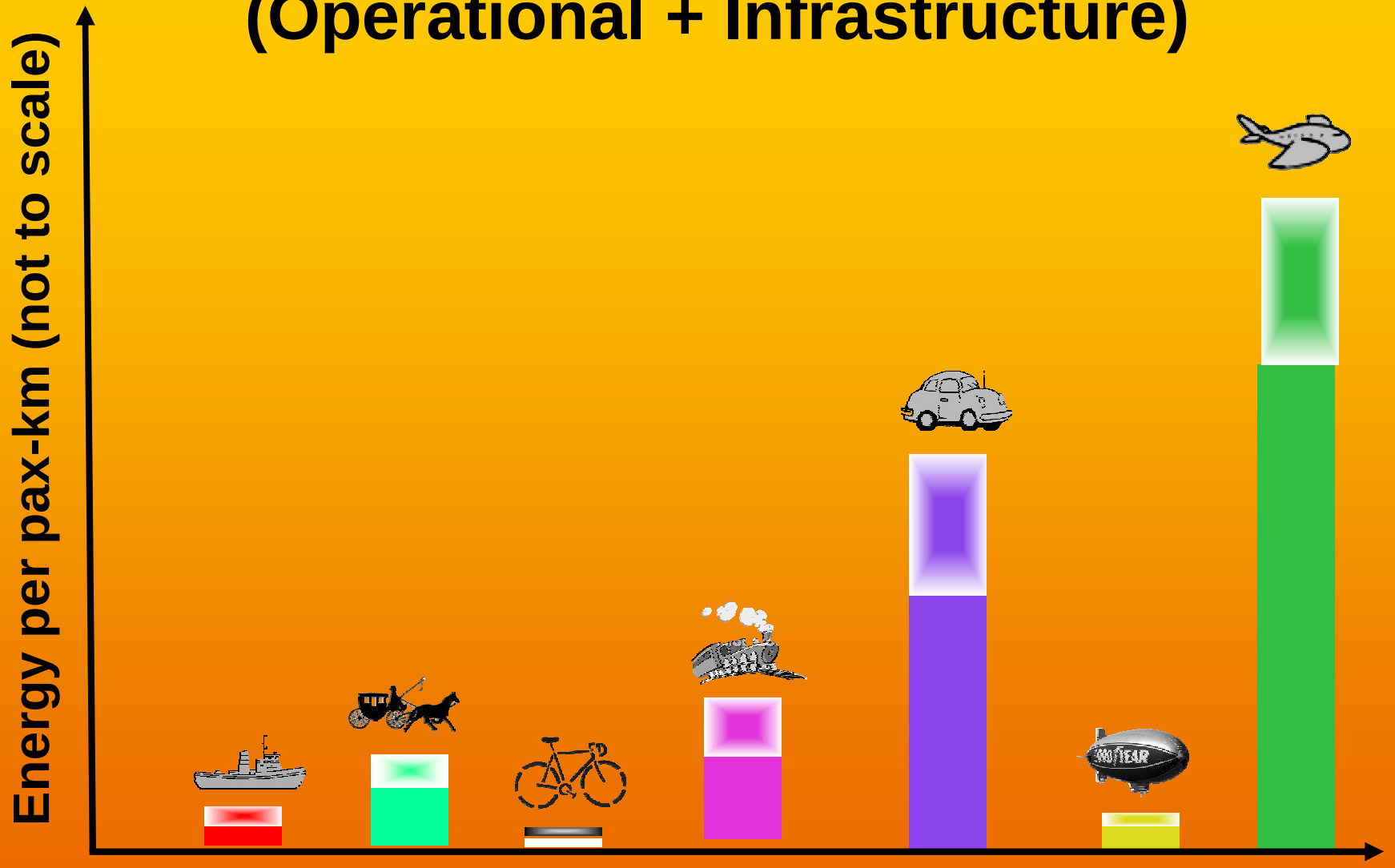
Development Alternatives

Energy Use in Transportation (Operational)



Development Alternatives

Energy Use in Transportation (Operational + Infrastructure)

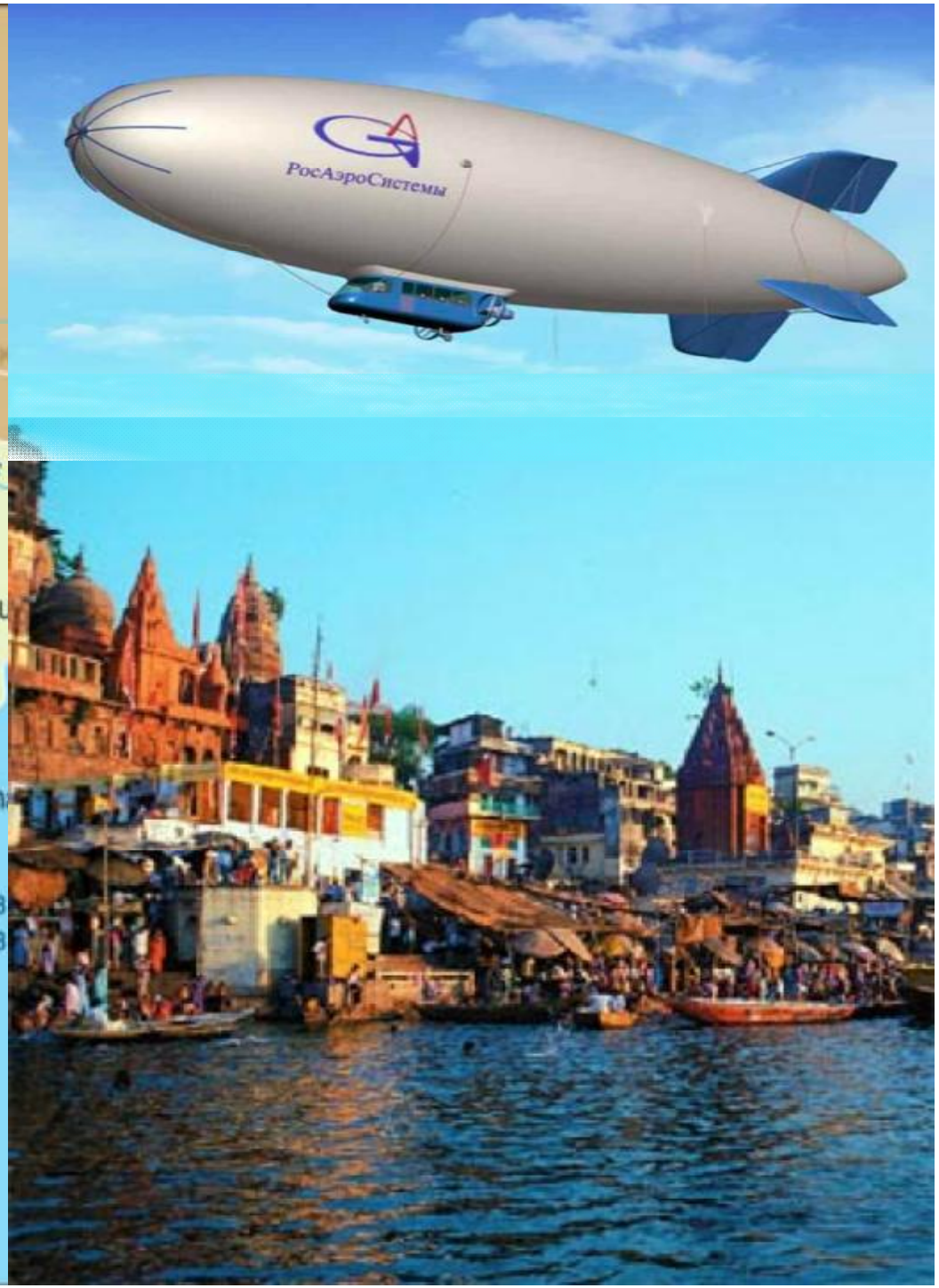


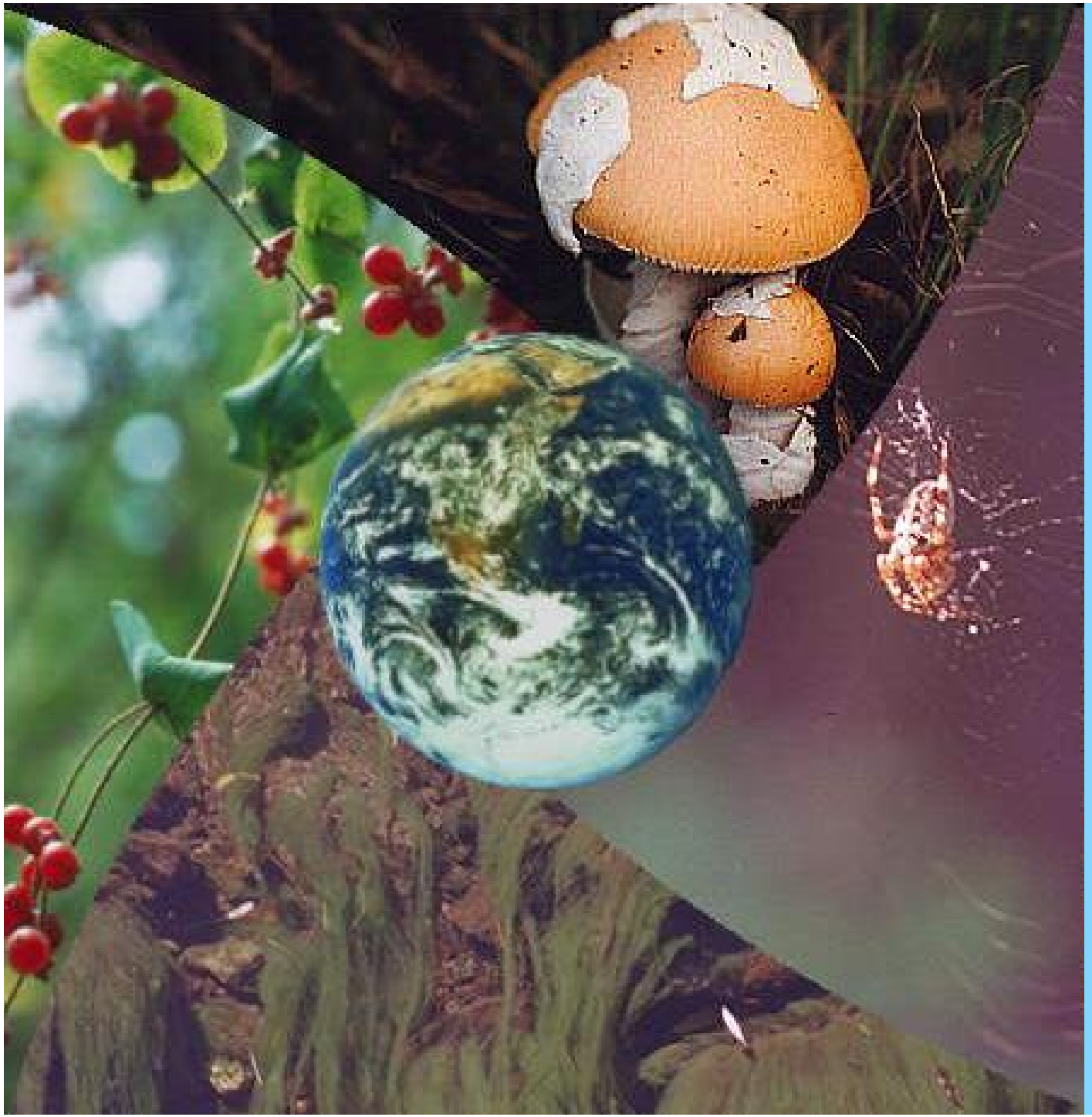
Development Alternatives

Energy Use in Transportation (Operational + Infrastructure + Rucksacks)

Development Alternatives


AFGHANISTAN
Srinagar
JAMMU AND KASHMIR
PAKISTAN
Amritsar
HIMALAYAS
NEW DELHI
THAR DESERT
RAJASTHAN
NEPAL
Jaisalmer
Jaipur
Agra
Kanpur
Ganges
INDIA
Varanasi
Udaipur
Kandla
Bhopal
Ahmadabad
Calcu
MAHARASHTRA
Nagpur
ARABIAN
Mumbai
SEA
Hyderabad
Vishakhapatn
Panaji
Marmagao
GOA
Bangalore
Chennai
Periyar Wildlife Sanctuary
Pondicherry
Calicut
Cochin (Kochi)
Madurai
KERALA
Trivandrum
Kovalam
SRI LANKA


РосАэроСистемы



The Five Kingdoms of Nature

*

- Animals
- Plants
- Fungi
- Algae
- Bacteria

*

ZERI

Water Supply for New York City circa 1997

Water Treatment Plant

Development Alternatives

Water Treatment Plant?

Development Alternatives

6.5 Billion Dollars

+ 300 Million Every Year

Development Alternatives

Development Alternatives

700 Million Dollars - One Time Investment

New York City: Value of Waterworks

Catskills: US $ 0.7 Billion

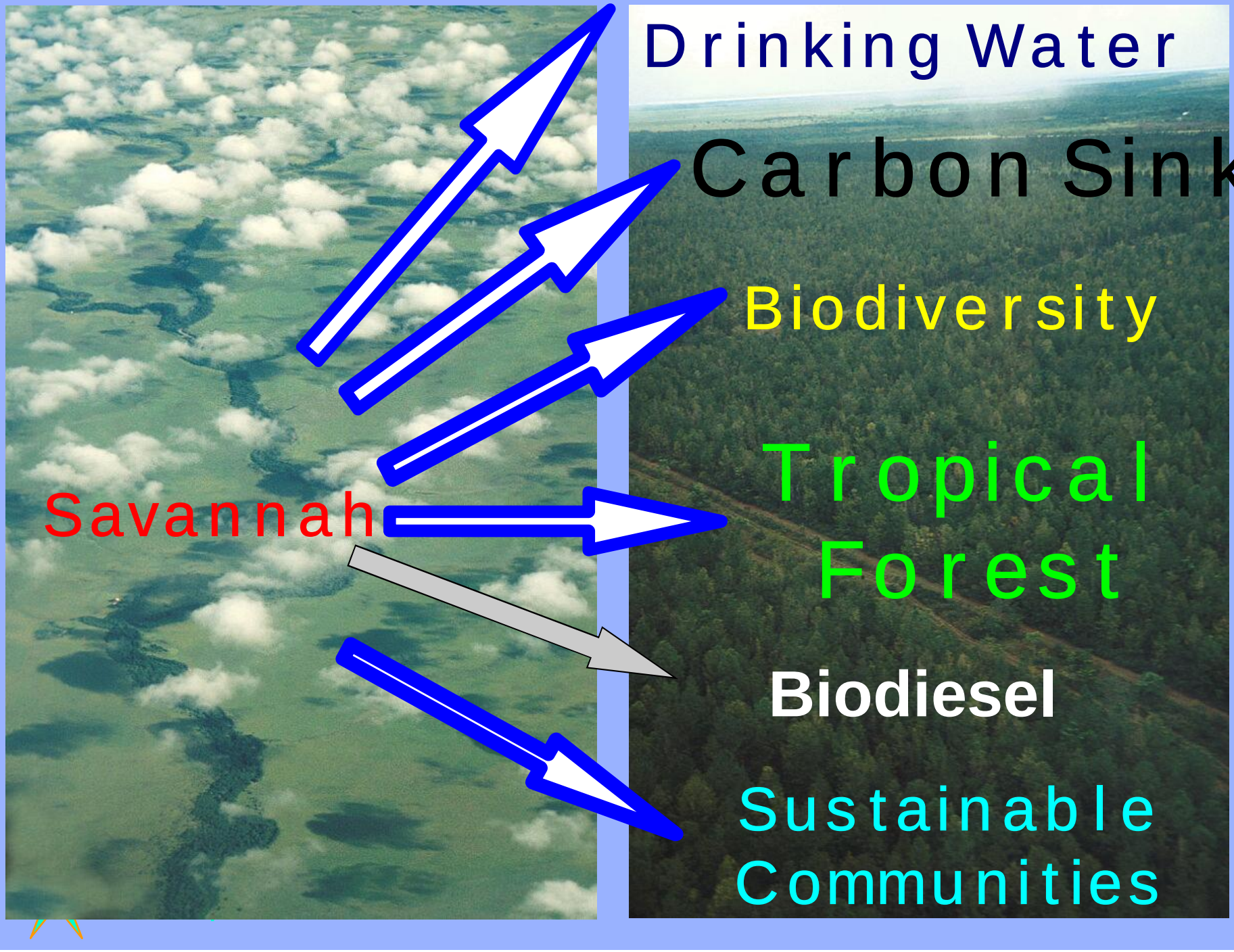
Engineered: US $ 6.5 Billlion

(Plus US$ 0.3 Billion/year)

Saving: US $ 6 Billion

Date: 1997

Estimated by: City of New York


Drinking Water
Carbon Sink
Biodiversity
Savannah
Tropical Forest
Biodiesel
Sustainable Communities

ZERI

BIOMIMICRY GUILD

Introduction

Innovation Today

Case Studies
Flame Retardant
Anti-bactericide
Pacemaker
Propeller Design
Water Efficiency
White color

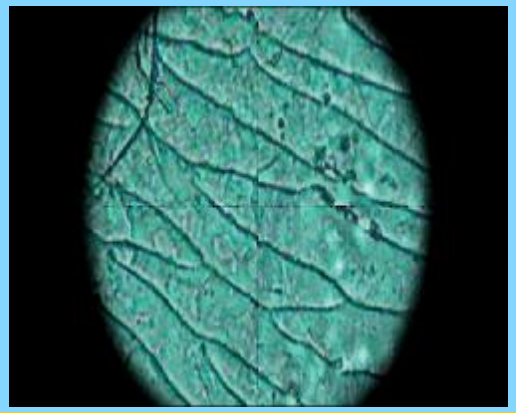
Solutions
from Nature

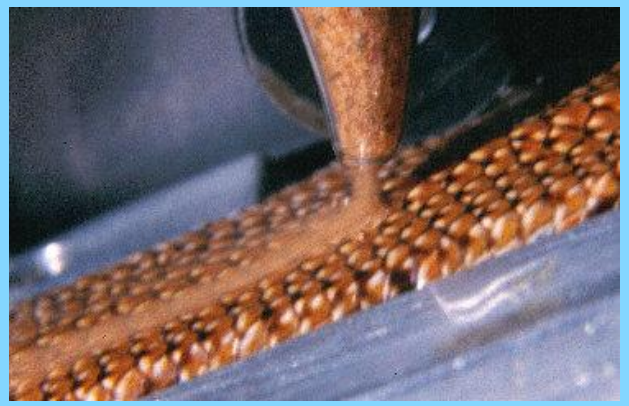
how can we have water without any pumps?

Welwitschia mirabilis in the Namib Desert

Development Alternatives

Anti-friction and Anti-abrasion without Ball Bearings or Lubricants (Outperforms Steel !)

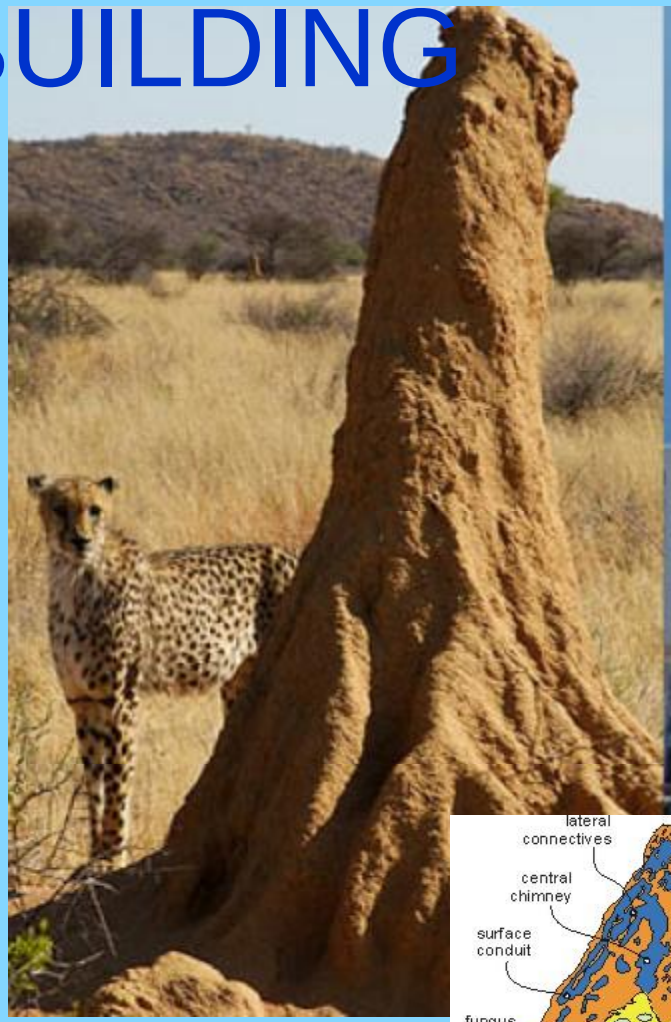


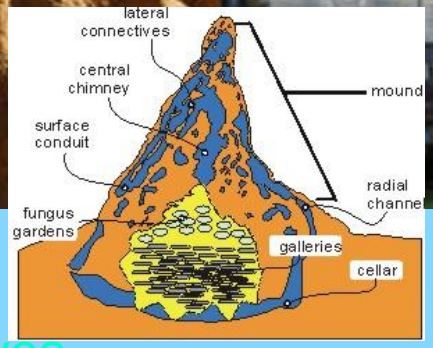


Technical University of Berlin

Development Alternatives

ENERGY EFFICIENT BUILDING





Warne, Nyquist, Pearce, Arup, etc.

Development Alternatives

Vaccines without Refrigeration

Cambridge Biostability

Development Alternatives

AUTOMOBILES

Daimler

Development Alternatives

Ways Forward
&
Research Agenda

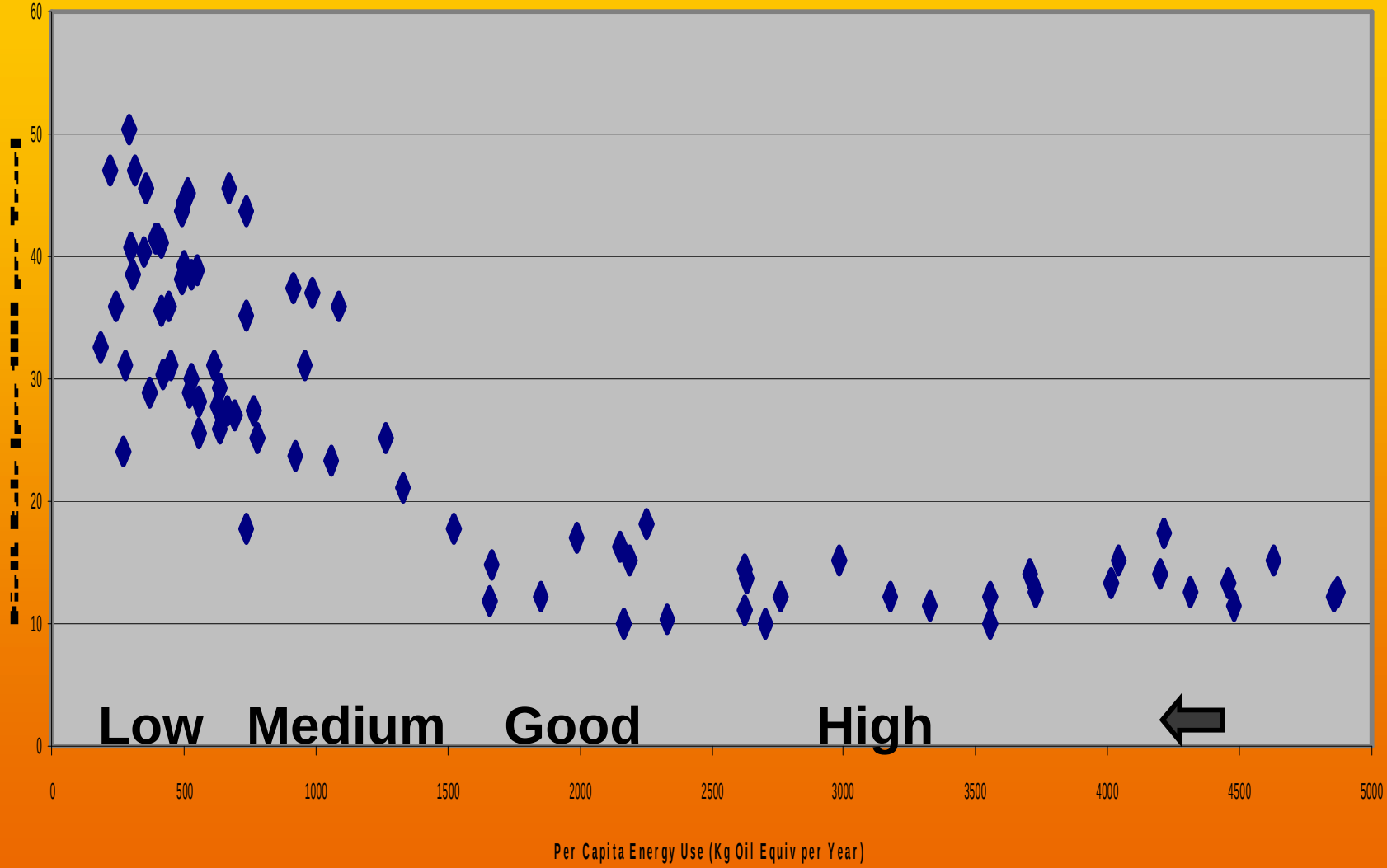
Development Alternatives

By 2050: Limits per Capita per Year

NR resources: (incl. rucksacks)	**6 tons**
CO_2 emission:	**2 tons**
Ecological footprint:	**1.8 Ha**
ENERGY USE	**2 kW ?**

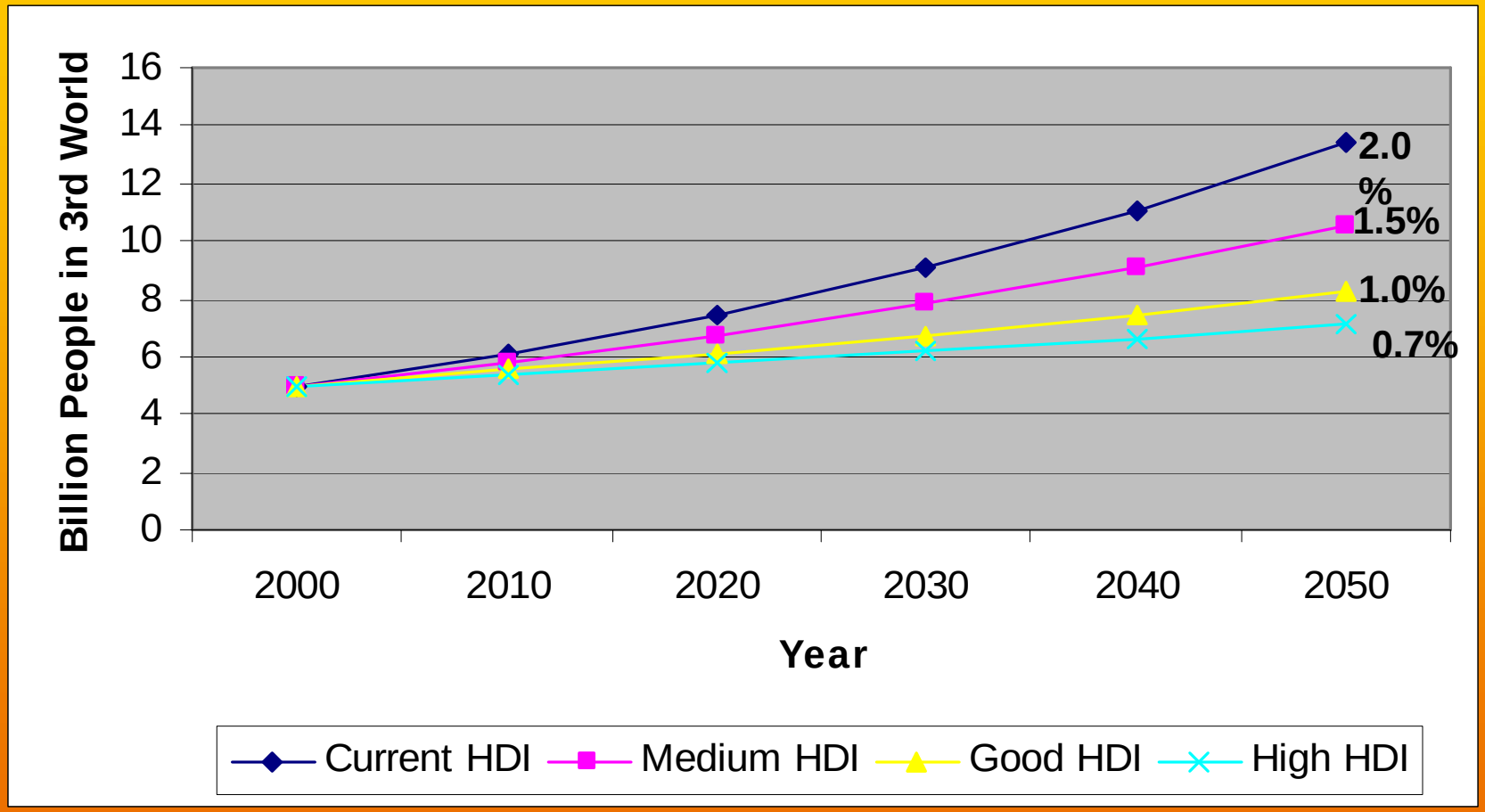
Development Alternatives

Human Fertility and Energy Use



Development Alternatives

HDI and Population Growth



Development Alternatives

3rd World in the Year 2050

If Low HDI (br = 2.0%) Continues: **13.5 Billion**

With rise to Medium HDI (br = 1.5%) **10.5 Billion**

With rise to Good HDI (br = 1.0%) **8.2 Billion**

With transition to High HDI (br = 0.7%) **7.0 Billion**

BAU ⇒ ***Several Billion Extra People***

Development Alternatives

Otherwise, We Will Need 2 Additional Worlds by 2030

Development Alternatives